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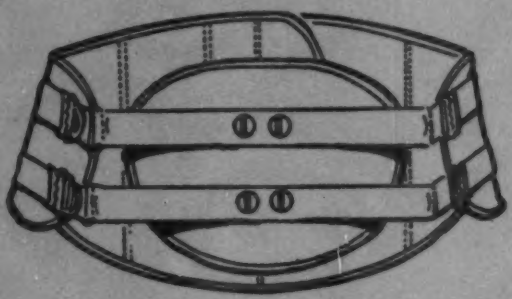

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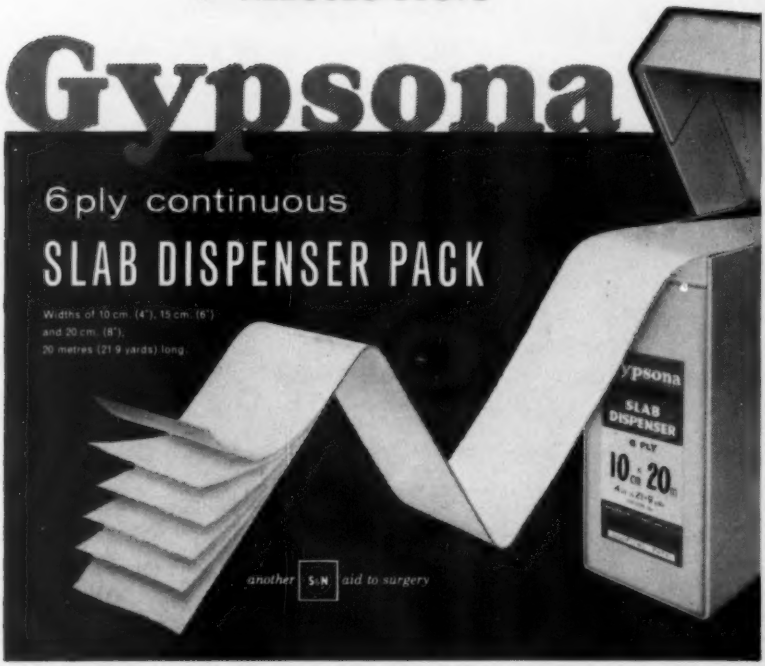

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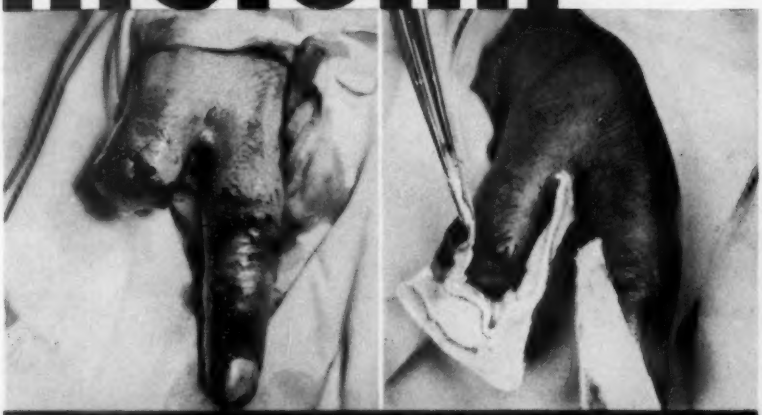

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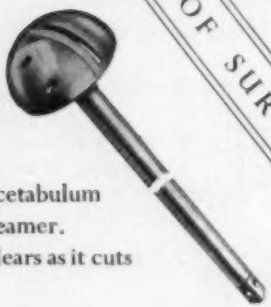

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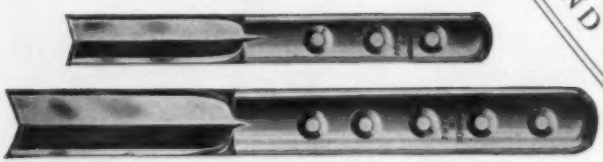

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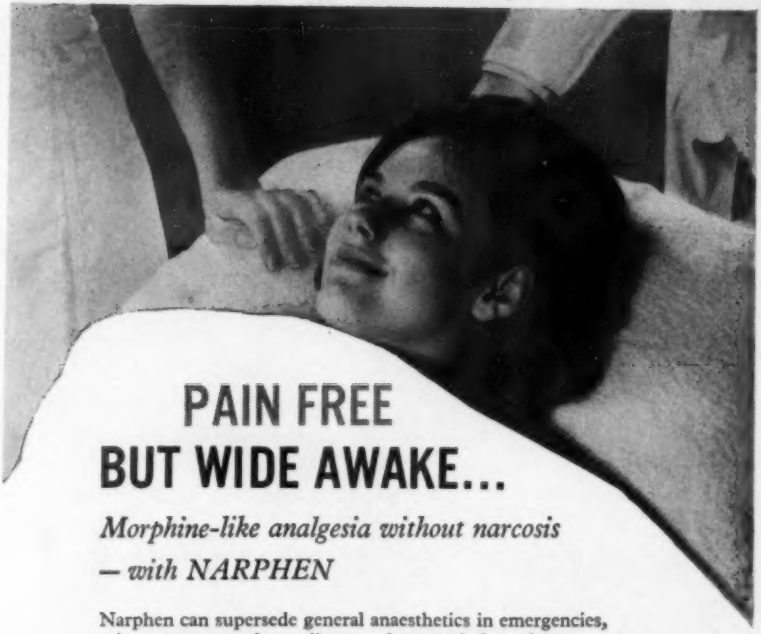

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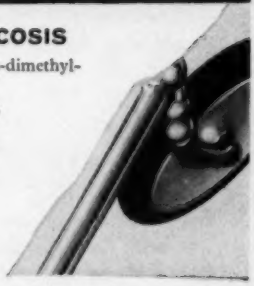

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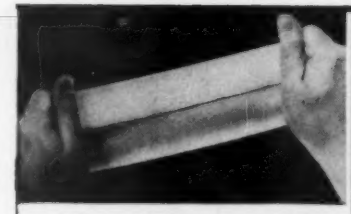

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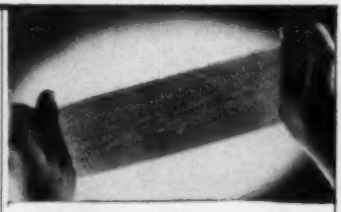

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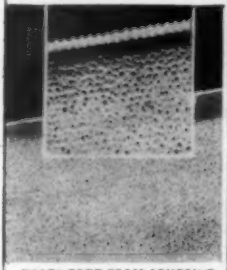

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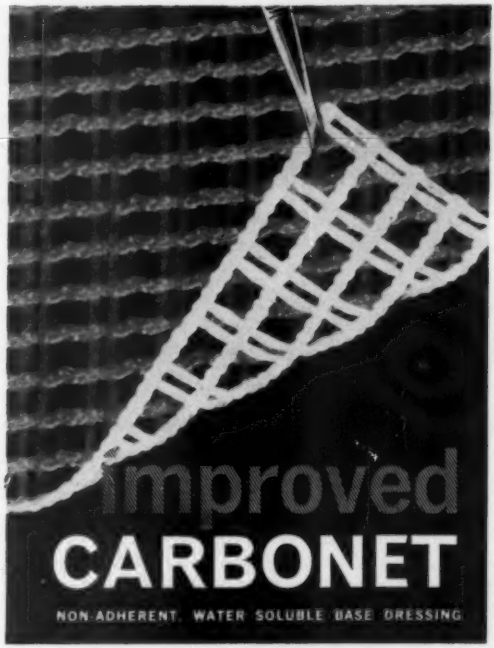

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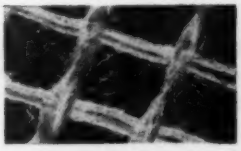

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ANNALS OF

THE ROYAL COLLEGE OF SURGEONS OF ENGLAND

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PATHOLOGY AND TREATMENT OF URETHRAL STRICTURE AND ITS COMPLICATIONS IN JAMAICA

Hunterian Lecture delivered at the Royal College of Surgeons of England

on

9th June 1960

by

P. A. M. Weston, F.R.C.S.

Lecturer in Surgery, University College, West Indies

IT IS A particular honour to be given the opportunity of delivering a Hunterian Lecture on urethral stricture and its complications, since it is a subject on which John Hunter wrote at considerable length in his treatise on venereal disease (Palmer, 1837). The disease in 18th century England evidently provided problems similar in regard to aetiology, pathology and treatment to those found in many underdeveloped countries to-day. Hunter's observations on the pathology of urethral stricture accompanied by fistulae are as pertinent to-day as when they were written two centuries ago.

Treatment at that time consisted chiefly of dilatation, a method which had been in use since the 6th century B.C. and is still in use to-day. If this method failed, the stricture was destroyed by caustic or, when fistulae were present, the tracks were laid open and external urethrostomy performed.

During recent years excision of the stricture with immediate or later reconstruction of the urethra has been practised. This has been made possible as a result of improvements in anaesthesia, advances in the techniques of plastic surgery, the advent of antibiotics, greater use of blood or fluid and electrolyte replacements, and better pre- and post-operative care based on a clearer understanding of the implications of impaired renal function and of the effects of a poor state of nutrition on wound healing. In the more advanced countries, where these methods have been developed, venereal disease clinics have greatly reduced the incidence of inflammatory stricture of the urethra. Indeed, traumatic stricture due to fractured pelvis or perineal injury, and especially to the passage of large endoscopic instruments along the urethra, is becoming more frequent as compared with inflammatory stricture (Marshall, 1958). In the less well developed countries, however, such as East and West Africa (McAdam *et al.*, 1949; Groh, 1952), Algeria (Sabadini, 1948), India (Gaikwad and Ormond, 1955) and Jamaica (McFarlane, 1952) inflammatory stricture of the urethra remains a great problem, and it is in these places that excisional methods of treatment will have their greatest application.

Jamaica is a mountainous sub-tropical island of nearly two million inhabitants, subsisting mainly on an agricultural economy. Communications are poor and hospitals and clinics are widely scattered and understaffed. Venereal disease is inadequately treated outside the main city of

Kingston, and the relationship of stricture of the urethra to gonorrhoea—which is known locally as " the gentleman's disease "—is not widely recognized. It is not surprising, therefore, that in Jamaica to-day, as in England a century or more ago, the disease is met with in its most advanced and often fatal form.

This lecture is based on a study of 66 male patients whose average age was 49 years who were suffering from severe or complicated inflammatory stricture of the urethra. These patients were seen in the University College Hospital of the West Indies between June 1956 and January 1959. Patients whose strictures could be treated by intermittent dilatation have been excluded from the series.

I hope to describe the pathological features encountered and to discuss the influence of these on the type of operation performed, since it was found that no one operation was suitable for all conditions which were seen. The following headings will be used for convenience and clarity:

1. Investigations, with special reference to urethrograms.
2. Aetiology, with special reference to lymphogranuloma venereum.
3. Pathological anatomy, with special reference to the origin and course of fistulous tracks.
4. Operative treatment:
   (*a*) Excision with immediate urethral reconstruction.
   (*b*) Excision followed by urethral reconstruction as a second stage.
   (*c*) Permanent diversion of the urine.
5. An analysis of the results will be followed by discussion and conclusions.

1. Investigations

The haemoglobin and blood urea were estimated and serological tests were performed as a routine. These included Gonococcal Complement Fixation Test, Lymphogranuloma Venereum Complement Fixation Test and Wassermann Reaction. Intravenous pyelograms and ascending and descending urethrograms were performed before and after the operation. The technique of urethrography which we found most satisfactory was as follows:

The urethra was anaesthetized with 4 c.c. of xylocaine jelly, following which a 12 per cent. solution of potassium iodide was injected under sufficient pressure to overcome the resistance at the stricture. Potassium iodide was found to produce as clear an outline as the more expensive dyes, and, being in aqueous solution, it was possible to penetrate and outline with dye all permeable strictures. Furthermore, its irritant properties were often responsible for inducing the patient to micturate, so that a descending urethrogram could be obtained.

Both ascending and descending urethrograms are necessary to produce good filling of the urethra on both sides of the stricture and to demonstrate its extent (Figs. 1 and 2). On one occasion, the use of this technique two

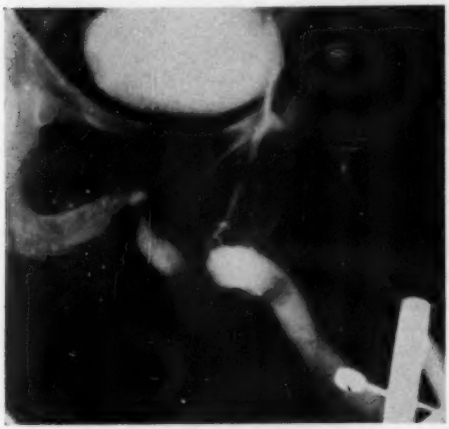

Fig. 1. Ascending urethrogram—D.R. The penile and distal parts of the bulbous urethra are well filled. The short strictured segment of the proximal part of the bulbous urethra is well shown, with poor filling of the membranous and prostatic urethra proximal to the stricture.

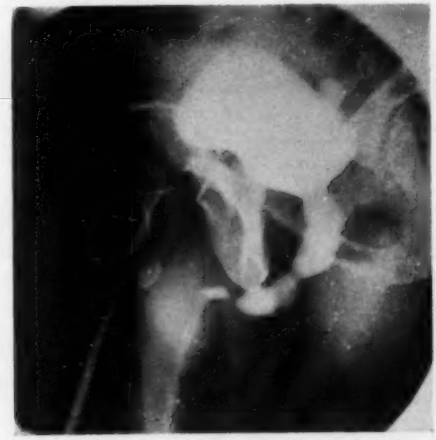

Fig. 2. Descending urethrogram—D.R. The dilated prostatic and bulbous urethra proximal to the stricture are well shown, with poor filling of the urethra distal to the stricture.

days after an unsuccessful attempt at dilatation resulted in dye escaping into the cavernous tissue of the bulb and thence into the veins (Fig. 3). A subsequent urethrogram performed one week after successful dilatation, and using the same technique, revealed little evidence of stricture or of extravasated dye. Toxic effects resulting from escape of topical urethral anaesthetic into the circulation were observed on several occasions in this hospital before xylocaine was available and may readily be explained on the basis of the above findings.

When it is impossible to introduce a cannula into the external meatus, owing to the presence of a meatal stricture or oedema of the external genitals, a roentgenogram of the proximal urethra and fistulous tracks may be obtained during the course of supra-pubic cystostomy by injecting radio-opaque dye down a Foley catheter which is inserted at the internal meatus, with the bag inflated.

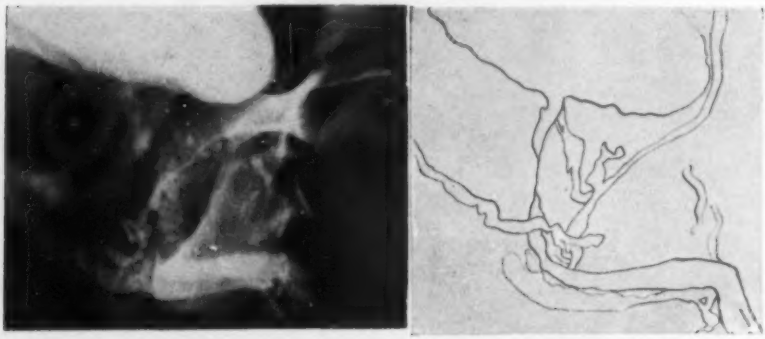

Fig. 3. Ascending urethrogram—U.C. The lumen of the urethra is shaded in the tracing taken from the roentgenogram. Dye has escaped into the cavernous tissue of the bulb and thence into the pelvic veins.

2. Aetiology

It has been suggested in many countries, including Sweden (Favre and Hellestrom, 1954), Hungary (Kleeberg, 1936), Africa (Sabadini, 1948), U.S.A. (Coutts, 1943, 1950) and Jamaica (McFarlane, 1952; Miles, 1957), that the more severe strictures with fistulae and lymphoedema are caused by the virus of lymphogranuloma venereum rather than by the gonococcus. Convincing evidence in support of this is lacking, however. It has not been possible, for example, to find any record of a patient with untreated lymphogranuloma venereum who had no evidence of having had gonorrhoea and who yet developed a stricture of the urethra. In the chronic stage the aetiology is obscured by secondary infection and histology is therefore of little value. There were 48 patients in whom serological

tests for both diseases were performed. There were 15 of these patients in whom both Gonococcal Complement Fixation Tests and Lymphogranuloma Venereum Tests were positive, eight in whom both were negative, and an intermediate number in whom one test was positive and the other negative (Table I). Further, it has been shown that up to 50 per cent. of

TABLE I

COMPLEMENT FIXATION TESTS

	+ LGV + GC	*— LGV — GC*	*+ LGV — GC*	*— LGV + GC*	*Total No. both Tests Recorded*
No Fistulae	3	2	3	6	14
Fistulae	12	6	8	8	34
TOTAL	15	8	11	14	48

apparently healthy factory workers in Kingston, Jamaica, have a positive L.G.V.C.F.T. (Segal). The value of serological tests in determining the aetiology of urethral strictures is, therefore, limited. There was no proven tuberculous stricture and there was no case of traumatic stricture in this series.

3. Pathological anatomy

The 66 patients have been grouped according to:

A—the site of the stricture (Table II); and

B—the presence or absence of fistulae or sinuses (Table III).

TABLE II

No of Patients — 66.
No. of Penile Strictures — 12.
No. of Bulbo-Membranous Strictures — 64.
No. of Multiple Penile and Bulbo-Membr. Strictures — 10.

TABLE III

Group	*Penile*	*Bulbo-Membranous*	*Multiple Penile Bulbo-Membr.*	*Total*
I. Stricture without fistulae	0	18	3	21
II. Stricture with fistulae ..	2	31	7	40
III. Fistulae without stricture	0	5	0	5
TOTAL	2	54	10	66

A. 64 strictures were in the region of the bulbo-membranous urethra. It was often difficult to determine the exact site of the stricture in relation to the external sphincter. In many, however, the stricture was short and was seen to be distal to the sphincter. Two patients in this series were treated for strictures of the penile urethra only. There were, however, 10 patients in whom both penile and bulb strictures were present. No stricture was encountered in the prostatic urethra. The terms anterior and posterior will be avoided in this lecture.

B. There were 21 patients in this series in whom an impassable stricture was not accompanied by abscess or fistula formation (Group I) and 45 in whom abscesses and fistulae were present (Groups II and III). Of these 45, a stricture was present in 40 (Group II). In the remaining five patients (Group III) there did not appear to be any appreciable degree of stricture, since a size 7/10 (E) bougie could be passed with ease into the bladder. The pathological anatomy of these three groups will be considered separately.

Group I. Strictures were found to be impassable for several reasons:

(i) the opening of the strictured segment was narrow and eccentrically placed in the urethra.

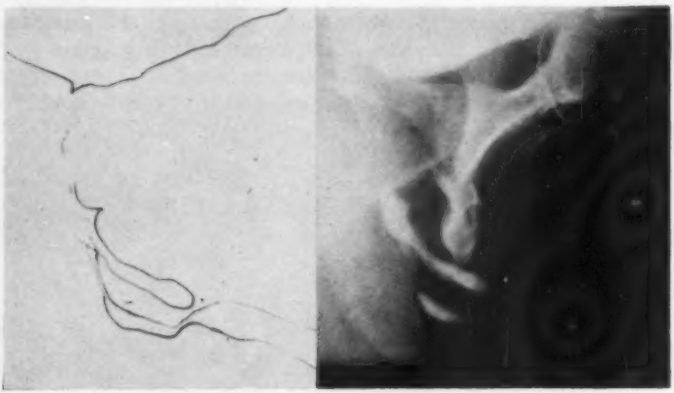

Fig. 4. False passage—M.W. Both the passages were excised and were shown to be completely epithelialized.

(ii) the strictured segment was not only narrow, but was long and tortuous.

(iii) a complete or incomplete false passage had resulted from previous unsuccessful attempts at dilatation (Fig. 4). The patient whose urethrograms are shown in Figure 4 gave a history of pain and swelling in the perineum following attempted dilatation. He was fortunate that the extravasation of urine and periurethral inflammation which must have followed the making of the false passage did not spread outside Buck's fascia towards perineal skin with resultant fistula formation (Tobin and Benjamin, 1944).

Group II. These patients have proved the most difficult to treat. Stricture and fistulae tend to recur even after laying open the tracks and excising the stricture. A study of the pathological anatomy of these 40

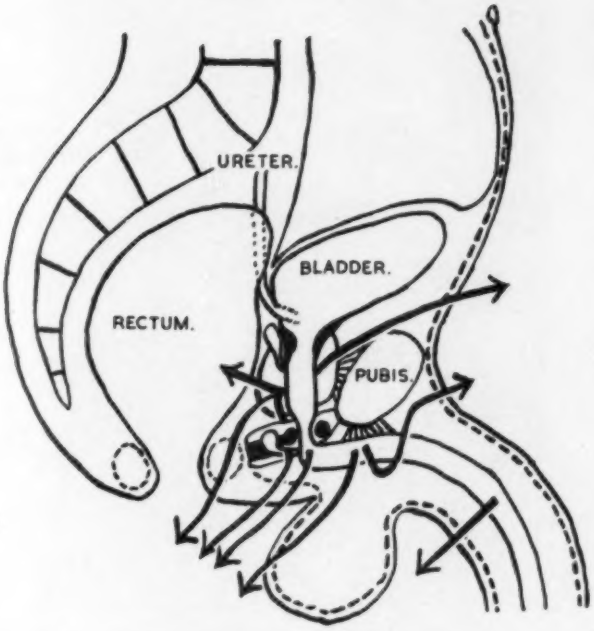

Fig. 5. Diagram of spread of fistulous tracks from the urethra.

cases was therefore made to determine if possible the origin and course of the fistulous tracks, and the reasons for failure of previous treatment.

(1) *Origin of fistulae.* Apart from these fistulae which opened on the shaft of the penis, the fistulous tracks appeared at operation to have originated from abscesses in the region of the bulbo-urethral glands, in the tissues around the bulbous urethra or in the prostate gland. In the absence of adequate dependent drainage into the urethra, these abscesses had discharged externally; and the process occurred in one of three ways. Sometimes it followed an attack of acute retention which was on two occasions accompanied by extravasation of urine, and gangrene of scrotal and perineal tissues caused by gas-forming anaerobic streptococci. Not infrequently, a history was obtained of an unsuccessful dilatation, which had been followed by fever, swelling and perineal pain, which had progressed until urinary fistulae appeared. Most commonly, however, a relatively slow and painless progression of the suppurative process resulted

Fig. 6. C.C. Multiple fistulous tracks, involving root of penis, scrotum, perineum, peri-anal region and inner side of thighs.

in the appearance of single or multiple fistulous skin openings. The internal opening of these tracks was either at the site of the stricture or proximal to it.

(2) *Clinical course and prognosis.* This depended on the institution of treatment in the early stages, since it was found that tracks of recent appearance showed some tendency to heal if the urine was diverted for several months by suprapubic cystostomy and the stricture was intermittently dilated. Once the disease had reached the chronic stage, however, even prolonged suprapubic drainage and dilatation of the stricture only reduced the activity of the infection whilst the fistulae remained open. There were two reasons for this—first, that the track had become epithelialized and, second, that a chronic thick-walled abscess remained undrained. These chronic lesions would only heal if all the tracks, all chronic abscess cavities and the diseased segment of urethra were removed. Some failures which have followed excision were probably

due to inadequate exposure of tracks leading from chronic abscesses in the prostate gland.

(3) *Anatomy*. At this point, I would like to examine the course taken by fistulous tracks in relation to different parts of the urethra. The diagram in Figure 7 indicates the different courses the tracks may follow. It must be realized that the position of the external openings is not an infallible guide to the course taken by the track on its way from the urethra, nor to the site of the stricture. The clinical findings must therefore be studied in association with the urethrograms. The following observations were, however, found to be fairly constant:

1. Tracks which open externally on the shaft of the penis or at its root were associated with a penile stricture. These tracks sometimes encircled the root of the penis to open close to the pubic eminence.

Fig. 7. T.B. Roentgenogram of silver catheter passing behind the base of the bladder from a stricture in the bulbous urethra.

2. Scrotal openings were usually associated with a track which passed to the bulbous urethra.

3. Perineal and peri-anal fistulous openings indicated tracks which passed to prostatic, membranous or bulbous urethra. The more extensive peri-anal fistulae which sometimes extended on to the thighs were always associated with prostatic abscesses (Fig. 6) and, conversely, if no fistulae were present posterior to a line joining the ischial tuberosities, the prostate gland was not involved in the suppurative process.

4. It will also be seen from the diagram (Fig. 5) that prostatic abscesses, in addition to passing downwards alongside the membranous urethra or through the levator ani muscle to the ischio-rectal fossae and so to the perineal or peri-anal skin, sometimes opened backwards into the rectum,

giving rise to a recto-urethral fistula, or forwards through the retropubic space to open on the lower anterior abdominal wall. There is yet one other possible route of spread of infection from the prostate gland, and this is upwards behind the base of the bladder into close relationship with the lower end of one or both ureters. The ureter may thus become surrounded by inflammatory tissue and obstructed. Seven patients in this group had a unilateral hydronephrosis, as compared with nine patients in Group I who had bilateral hydronephrosis. This suggested that some factor other than urethral obstruction might be responsible for the unilateral hydronephrosis. In two such patients with fistulae and unilateral hydronephrosis an opportunity was afforded of examining the lower end of the affected ureter. The findings were similar in both. One will therefore be briefly described.

Fig. 8. Descending urethrogram—J.D. No fistulae were present in this patient and the urethra proximal to the stricture in the bulbous urethra is greatly dilated.

Case History. L. W., aged 65, was admitted with multiple fistulous tracks opening on to peri-anal, perineal, scrotal and suprapubic skin. There was an area of narrowing in the bulbous urethra which was, however, easily negotiated with a 7/10 (E) bougie. The state of nutrition of this patient was very poor and the urine was infected. The blood urea was 24 mgm. per cent., haemoglobin was 9.7 G. per cent., I.V.P. showed a normally functioning right kidney, but there was no excretion of dye from the left side. Cystourethroscopy revealed a scarred irregular bladder. There was a well marked epithelialized false passage passing from the prostatic urethra into the base of the bladder. A suprapubic cystostomy was performed. Three days after this he developed a severe urinary infection and died in uraemic coma. Post-mortem examination showed that the lower end of the greatly dilated left ureter was buried in tough pelvic cellular tissue infiltrated with chronic inflammatory cells. There was no evidence of stone or growth. A congenital abnormality could not be excluded, but it seemed likely that the obstruction to this ureter was inflammatory, and that this may have been the result of the passage of a bougie outside the urethra behind the bladder. The course taken by a bougie passing

in this way outside the urethra and re-entering the base of the bladder is shown in the accompanying roentgenogram (Fig. 7). The case history of this patient was as follows:

T.B., aged 72 years, a veteran of the 1914-18 War, came to this hospital unable to pass water. His bladder was found to be distended with blood clots. Examination under anaesthesia revealed that there was an impassable stricture in the region of the bulbo-membranous urethra and an extensive growth on the anterior bladder wall, which made suprapubic cystostomy impracticable. A fine metal bougie was then forced past the stricture in the urethra and on into the bladder. This was followed by a silver catheter through which the bladder was washed clean and drainage of urine established. The roentgenogram shown in Figure 7 was taken two days later and shows the catheter leaving the urethra at the level of the stricture, passing posterior to the bladder neck and re-entering the base of the bladder. Total cystoprostatectomy and transplantation of the ureters were performed three days later, from which recovery was uneventful.

Fig. 9. J.E. Roentgenogram of stone containing the head of a de Pezzer catheter.

These observations indicate that dilatation of the upper urinary tract may not always be due to the urethral stricture alone, and that inflammation around the base of the bladder, spreading from the prostate gland and sometimes initiated by the making of a false passage, may result in obstruction to the ureter. In such patients, re-implantation of the ureter or nephrectomy may be required in addition to treatment of the stricture of the urethra.

Group III. In all five patients the fistulous tracks were related to the bulbo-membranous urethra, which was the seat of disease. In each there was a history suggesting the presence of a urethral stricture in the past. The lymphogranuloma venereum complement fixation test was positive in two patients. Epithelialization of the tracks was shown to have occurred in four. The upper urinary tract was normal in four. Thus the ill effects were confined to the inconvenience of the chronic discharge in the perineum and the presence of a chronic cystitis. It is interesting that such a degree of spontaneous resolution of the stricture may not infrequently take place.

Complications other than fistula formation

1. *The effects of back pressure.* The urethra proximal to an untreated stricture may become very dilated (Fig. 8). It is in this type of patient that perineal puncture, as performed by Cock and many others for the relief of acute retention of urine, would have been most successful (Attwater, 1943). This operation was not performed on any patient in this series, since it was not possible to judge on clinical grounds the extent and degree of dilatation of the urethra proximal to the stricture. Diverticulum of the bladder (single or multiple) was seen in eight patients. Hydronephrosis (unilateral or bilateral) was seen in 16 patients. In only three patients were diverticulum and hydronephrosis found together in the same patient. It should be noted that the development of fistulae may for a time protect the upper urinary tract from the effects of back pressure.

2. Stones were found in the bladder four times and in the dilated proximal urethra three times. These stones were not always radio-opaque and failure to remove them with the fistulous tracks could result in recurrence of sinuses or fistulae.

3. Elephantiasis was seen in two forms—a gross, hard, irregular oedema which sometimes became ulcerated, and an extensive soft pitting oedema affecting the scrotum or penis or both. The latter type of lesion was also encountered in the absence of a urethral stricture. Since filariasis is unknown in Jamaica, the aetiology of this soft type of oedema remains obscure. However gross the oedema and however extensive the associated fistulous tracks might be, excision of all diseased scrotal skin and subcutaneous tissues has always disclosed normal testicles and a normal shaft of penis, which could be stripped easily away from the overlying diseased tissues.

4. Gangrene of the scrotum and perineum, caused by anaerobic gas-forming streptococci has been mentioned previously. Both patients recovered after wide excision of the tissues involved.

5. Associated tuberculous lesions of lung, spine, kidney or epididymis were found in four patients. No definite evidence of tuberculous infection was found on histological examination of the excised portions of urethra and peri-urethral tissues.

6. *Carcinoma.*

(*a*) *Urethra.* Squamous cell carcinoma of the urethra ulcerating through the shaft of the penis was seen in two patients.

(*b*) *Bladder.* Squamous cell carcinoma on the vault of the bladder developed in two patients. The following observations have been made in relation to carcinoma of the bladder in Jamaica:

1. The overall frequency of carcinoma of bladder in Jamaica is similar to that elsewhere (Clemmeson and Nielson, 1952), but the number of patients with simple papilloma of the bladder is low.

2. Six out of a total of 22 male patients treated in this hospital during the last seven years for carcinoma of bladder had also been treated for many years for stricture of the urethra.

3. All but one of these six patients had a squamous celled growth situated well away from the base of the bladder.

4. Pale patches of squamous cell metaplasia of the bladder mucosa have been found on the posterior wall or vault in two patients of this series who were suffering from chronic cystitis associated with urethral stricture.

5. Schistosomiasis (Prates and Gillman, 1959) is not seen in Jamaica.

It is suggested, therefore, that cystitis accompanying stricture of the urethra is an important aetiological factor in carcinoma of the bladder in Jamaica. Similar observations have been reported from East Africa (Davies, 1957). Every case of chronic cystitis due to urethral stricture should therefore have a periodical endoscopic examination of the bladder to exclude carcinoma.

4. Treatment

For many centuries dilatation of urethral strictures has been practised with variable skill and equally variable success. A certain proportion of strictures, however skilled the operator, are impassable and some are also impermeable. As described so clearly by John Hunter, these patients can be relieved temporarily by opening the dilated urethra proximal to the stricture, or by external urethrostomy. The latter procedure, however, has certain disadvantages. The stricture tends to recur and requires intermittent dilatation. It has been found also that laying open fistulous tracks combined with external urethrotomy may be followed by recurrence of the fistulae as well as of the stricture. This happened in two patients in the present series. One patient from whom two peri-urethral calculi were removed in the course of external urethrotomy for a stricture in the bulbous urethra developed a peri-urethral diverticulum. This has to be emptied by manual pressure after micturition, but is otherwise no disability. To improve these results, excision of the stricture has been practised. Degas was the first to record excision of a stricture in 1836 (Attwater, 1943). Hamilton Russell in 1915 described an operation for reconstruction of the urethra, following excision of a stricture. He united

only a part of the circumference of the cut ends of the urethra, leaving this strip of epithelium to spread circumferentially, thus completing the repair of the urethra. He found that a stricture was less likely to recur after this operation than after end-to-end anastomosis. This method of reconstruction cannot be applied if the urethral ends cannot be approximated. Denis Browne in 1949 found that not only urethral mucosa but a strip of penile skin will spread circumferentially to re-form a tube. He used this principle in the treatment of patients with all degrees of hypospadias. A strip of skin, in continuity with the abnormal opening and extending to the tip of the penis, was outlined on the ventral surface of the penis, and buried by undermining the lateral skin flaps which were approximated in the midline. A dorsal relieving incision ensured that post-operative oedema did not cause tension on the suture line. The results of this operation were so successful that Swinney in England (Swinney, 1952, 1957) and Johanson in Sweden (Johanson, 1953) applied the same principle in the treatment of severe urethral strictures. At a first stage, the diseased portion of urethra was either excised or laid open on its ventral surface. The two cut ends or the cut edges of the urethra were then sutured carefully to penile (or scrotal) skin. This resulted in two urethral openings separated either by a narrow strip of urethral mucosa or by penile skin. This now presented a situation which was similar to that seen in hypospadias.

At a second stage some weeks or months later, a strip of skin (with or without urethral mucosa) was outlined in continuity with both urethral openings. This strip was buried by undermining the penile skin on either side of the strip and suturing the edges in the midline. A dorsal penile incision was performed to relieve tension at the suture line. This operation was a great advance in technique and has been used in this series on 12 occasions. However, in common with other surgeons, certain difficulties have been encountered—fistulae may form on the ventral surface of the penis at the site of the suture tracks. Further, and more important, if the disease extends back into the bulbous, membranous or even prostatic urethra, it is difficult to obtain a skin-to-mucosa union which does not tend to contract and form a new stricture. Johanson's method involved suturing at the bottom of a scrotal tunnel. Swinney gained exposure by splitting the scrotum, Hamilton Stewart (1960) by making two incisions—anterior scrotal and perineal. Turner Warwick (1960) uses a scrotal skin flap to effect the skin-to-mucosa union and to bridge the gap between the two urethral openings. All these methods have been utilized in this series as the occasion demanded. When there was insufficient local skin available after an extensive resection, free split skin grafts or pedicle grafts from the thigh or from the foreskin were used. Such extensive removal of skin may be necessary when elephantiasis of scrotum and penis is present. The theoretical disadvantage of burying hairy scrotal skin in the second stage operation has not, in practice, resulted in stone formation. It is not always easy to judge correctly the size of the skin strip to be buried. In

one patient too large a buried strip resulted in a large tortuous reconstructed segment of urethra, which has to be emptied manually, but is otherwise no handicap to the patient.

In view of these difficulties, and because it was found that many bulbomembranous strictures were short, however extensive abscess and fistula formation might be, it was decided to approximate the cut ends of urethra in one stage whenever this was possible. In most patients anastomosis was possible in the proximal part of the bulbous urethra or in the region of the membranous urethra (external sphincter muscle). The anastomosis was sometimes performed following Hamilton Russell's technique and sometimes end-to-end anastomosis was completed over a catheter using a continuous mucosal layer of 4/0 atraumatic plain catgut, reinforced by interrupted chromic catgut sutures in the tissues of the bulb. The catheter was removed at the end of the operation. In some patients, the resection has necessarily resulted in the removal of a large part of the perineal musculature together with the membranous urethra, and has extended into the prostate gland and prostatic urethra. In three such patients, penile urethra distal to the excised segment of urethra has been mobilized and drawn into the prostatic urethra on a Foley catheter secured to the anterior abdominal wall, as in Badenoch's operation for traumatic stricture of the urethra (Badenoch, 1950; Silverton, 1954). These patients have remained continent of urine. As Hugh Young pointed out when describing extensive resections for gunshot wounds (Young, 1942) and carcinoma (Young, 1939) of the urethra, end-to-end anastomosis is often possible after resection of more than two inches of urethra. Furthermore, he pointed out that the shortening of the penis corrects itself in a remarkable way in time. The extent to which this occurs depends on the initial length of the urethra. These observations have been confirmed in this series.

Pre- and post-operative care

Since many of these patients presented with discharging sinuses or fistulae so that the incisions sometimes approached the anal margin, the precaution was taken of sterilizing the rectum pre-operatively by giving oral streptomycin (Grams 1 twice daily) and administering a sulphadimidine rectal washout on the two days prior to operation. It was then possible to insert a finger in the rectum to facilitate deep dissection in the perineum (which was required to expose membranous or prostatic urethra) without increasing the risk of wound infection. Free drainage from these wounds was important. There was considerable oozing of blood and exudate from the operation site for which small drains at the angles of the wounds were found to be inadequate. When a portion of the wound was left open and packed lightly, no trouble was encountered from haematoma formation followed by wound infection. Antibiotic cover was given as a

routine. Transfusion of one or two pints of blood was sometimes necessary.

If suprapubic cystostomy had not already been established, it was performed at the time of the excisional operation, since it was found that urethral wounds healed well when there was no soiling with urine and when no drainage catheter was left across the suture line. The duration of the suprapubic diversion of the urine varied from a few days (after the first stage of the Swinney-Johanson procedure) to three weeks following the second stage operation or following end-to-end anastomosis in one stage. The length of this period of drainage depended on the disappearance of discharge from the urethra (which was irrigated gently every other day) and on the ease with which a bougie could be passed. Prolonged suprapubic diversion of the urine before undertaking excision was necessary in the presence of a damaged upper urinary tract, in the presence of severe or active perineal inflammation in association with fistulae, and when the patient's state of nutrition was so poor as to contraindicate any major operative interference. A number of these unfortunate people were social outcasts unable to find more than an occasional breadfruit or mango to support life.

Permanent diversion of the urine

This brings me to the treatment of patients who are unsuitable for a major operation because of age, associated disease, malnutrition or uraemia. Some form of permanent diversion of the urine was necessary for these very ill patients. Perineal urethrostomy was the best procedure when sufficient healthy perineal skin and a sufficient length of healthy urethra proximal to the stricture were available. Suprapubic cystostomy, as ordinarily performed, was unsatisfactory because of the risk of stone formation and infection. The roentgenogram shown in Figure 9 was taken of a patient who tired of his supra-pubic tube and cut it off flush with the skin with his cutlass. Two years later he returned for treatment of his stricture. The stone surrounding the head of the de Pezzer catheter is well seen. A straight Jaques catheter which can be removed, boiled and replaced twice a week by the patient, was found to be an improvement on the self-retaining catheter which must be changed in hospital. A fistulous opening can be made between bladder and supra-pubic skin, which is lined by epithelium. An ileostomy bag is worn to collect the urine. This relatively small operation avoids a granulating surface as well as avoiding a catheter in the bladder. In two out of three patients in whom this operation has recently been performed the result has been satisfactory, in so far as the urine has become clear and the patient can remain dry. The details of a more elaborate technique for performing such an operation have been described by Lapides *et al.* (1960).

Type of operation performed

Excision with end-to-end anastomosis was the commonest operation performed. The two-stage procedure was performed with greater frequency in those patients with fistulae than in those without. External urethrostomy was performed in the early part of the series on six occasions. Permanent diversion of the urine was performed eleven times, the commonest procedure being a perineal urethrostomy (Table IV). Internal urethrostomy was not performed on any of these patients because the strictures encountered were either impassable or were easily dilated.

TABLE IV

	Types of Operation Performed				
	One-Stage Excision	*Two-Stage Excision*	*External Urethrotomy*	*Permanent Diversion*	*Total*
Fistulae absent	15	3	2	1	21
Fistulae present	22	9	4	10	45
Total	37	12	6	11	66

5. Results

The results of treatment are difficult to assess in this series, since the criteria used in selecting the type of operation and the techniques employed underwent some modification as a result of increasing experience. In all patients in whom permanent diversion of the urine was performed the object of the operation was achieved, although in some patients it has been necessary to dilate or revise the opening of the perineal urethrostomy. In only two of the six patients in whom external urethrostomy was performed was a lasting good result obtained and in both patients the operation was performed for peri-urethral calculus in the presence of a dilatable stricture.

In only 34 out of 49 patients (just over two-thirds) was a follow-up of longer than six months obtained. One of the great problems in the treatment of urethral strictures (as indeed of every other disease in Jamaica) is the irregularity of attendance at the hospitals and clinics. The result of treatment was classed as good if the stream was strong, the urine clear, there was no recurrence of fistulae or sinuses and a bougie only needed to be passed at a six-month interval or longer. It can be seen from Table V that the number of patients with a good result is greater in those in whom the one-stage procedure was performed than in those in whom the two-stage procedure was performed. Further analysis of these figures (not shown in the table) indicated, as would be expected, that the results were better in those patients without fistulae (Group I) than in those with fistulae (Groups II and III).

It will be seen from the last column of the table that nearly 90 per cent. of these patients were improved, in that fistulae had not recurred, and the stricture instead of being impassable was now being dilated at intervals of six weeks to six months. This result was the same irrespective of which

of the two procedures was used. It would perhaps be invidious to add that it is hardly possible to make these patients worse. There were, however, two patients in the series who died.

TABLE V

	No. of ops. performed	*Six months follow-up or longer*	*No. of good results*	*No. of good or moderate results*
One-stage procedure	37	27	16 (59%)	24 (89%)
Two-stage procedure	12	7	2 (29%)	6 (86%)
TOTALS	49	34 (69%)	18 (53%)	30 (88%)

The first was one of the earliest operations performed; he died 24 hours after operation. He was uraemic, his state of nutrition was poor, and he should probably not have been submitted to a major surgical procedure. The second patient had associated tuberculous lesions in lungs and spine. He died of jaundice six months after the successful resection of his urethral stricture and the complicating urinary fistulae.

Of the good results, one man who had been debarred from driving a railway engine because his stream could not clear the footplate, related with pride how his neighbours cheered his success in hitting the back wall of his yard at 10 feet. Another has returned to his occupation as a saddler for Her Majesty's forces in Jamaica, whilst yet another has for the first time in five years become socially acceptable in his home and is able to earn an honest living to send his six children to school.

Discussion and conclusions

Excisional treatment of impassable strictures without fistulae is likely to be successful provided the operation which is chosen is performed carefully. The patients with fistulae are a more difficult problem, and success would seem to depend on the following measures:

1. Careful pre-operative assessment of

(*a*) the degree of active inflammation present in the lesion and its extent,
(*b*) the condition of the kidneys, and
(*c*) the patient's general health.

Some improvement in the first two may be expected to follow a period of suprapubic diversion of the urine and the last may improve with a period of rest in hospital and good food, when these are available.

2. Attention to details of operative technique including the following:

(*a*) complete excision of diseased tissues,
(*b*) adequate wound drainage, and
(*c*) the early removal of catheters across urethral suture lines.

As a result of experience with these patients, dilatation must still be regarded as the treatment of choice provided a bougie can be passed. It would seem that external urethrotomy may occasionally be usefully employed for the removal of urethral or peri-urethral calculi, or for the removal of the occasional single fistulous track in the presence of a dilatable stricture. Excisional surgery is indicated for all impermeable and impassable strictures without fistulae. It is indicated in the treatment of all strictures complicated by fistulae, except when a dilatable stricture is complicated by fistulae of recent origin. Under these circumstances, healing may occur after temporary suprapubic diversion of the urine.

Excision and anastomosis in one stage is advisable for the short bulbo-membranous strictures with or without fistulae. Two-stage excision and urethral reconstruction is necessary for the long or multiple stricture, and for the strictures in the penile urethra.

Permanent diversion of the urine may be obligatory when more extensive surgery would be dangerous or is refused.

Summary

1. The pathology and treatment of 66 severe or complicated strictures of the urethra are reviewed.
2. There is little evidence from this series that lymphogranuloma venereum is an important cause of urethral stricture and its complications.
3. The importance of avoiding the formation of false passages with bougies is emphasized.
4. Fistulous tracks fall into definite patterns. A study of these in association with the urethrograms will allow pre-operative assessment of the extent of the lesions, and therefore of the extent of resection likely to be required.
5. The suggestion is made that when unilateral hydronephrosis is present, obstruction at the lower end of the affected ureter is sometimes the result of infection which spread from the prostate gland or which was initiated by the passage of a bougie outside the urethra posterior to the base of the bladder.
6. Patients with long-standing cystitis in association with stricture of the urethra may develop a carcinoma which is usually squamous celled and situated away from the base of the bladder.
7. Impassable strictures and those complicated by fistula and abscess formation are best treated by excision and anastomosis in one stage when short and situated in the bulbo-membranous urethra, and by two-stage excision and reconstruction when long, multiple or in the penile urethra.

My thanks are due to my colleagues in Jamaica for their encouragement and constructive criticism; also to the nursing and theatre staff for their skill and patience in dealing with these unpleasant lesions; and last, but by no means least, to those patients (to whom the name was never better applied) who did attend the clinic to complete their treatment.

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APPOINTMENT OF FELLOWS AND MEMBERS TO CONSULTANT POSTS

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The Editor is always glad to receive details of new appointments obtained by Fellows and Members, either through the Hospital Boards or direct.

THE DISTRIBUTION OF INSPIRED GAS DURING THORACIC SURGERY

Hunterian Lecture delivered at the Royal College of Surgeons of England
on
24th November 1960
by
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HISTORICAL BACKGROUND

JOHN HUNTER LIVED during the period in which the purpose of respiration was discovered. This advance in knowledge was dependent upon the development of gas chemistry, and the biological significance of oxygen, carbon dioxide and nitrogen was studied almost immediately after these gases were isolated. At first, the purpose of respiration was explained according to the phlogiston theory. Priestley, in particular, held steadfastly to this theory and in 1776 suggested that the purpose of respiration was:

> " to carry off the putrid effluvium or to discharge that phlogiston which had been taken into the system with the aliment."

It was also in 1776 that John Hunter published his proposals for the Recovery of People Apparently Drowned. This paper contains two remarkable suggestions. The first was that oxygen might be valuable for resuscitation.

In a footnote he suggests: " Perhaps the dephlogisticated air, described by Dr. Priestley may prove more efficacious than common air. It is easily procured, and may be preserved in bottles or bladders."

His second suggestion was the use of a subatmospheric pressure to assist expiration in cases of respiratory failure. This raised a controversy which has lasted to the present day and anaesthetists still argue the advantages and disadvantages of the negative pressure phase during artificial ventilation.

Hunter made yet another major contribution to respiratory physiology—one which would appear to derive from his more familiar role as a comparative anatomist. It concerns the relative distribution of the air and blood within the lungs—an aspect of respiratory physiology which has been neglected until recent years. Even now, it is doubtful if one could improve on Hunter's lucid account of the concept of distribution:

> " In animals where there is no circulation there can be no lungs; for lungs are an apparatus for the air and blood to meet, and can only accord with motion of blood in vessels. . . . As the lungs are to expose the blood to the air, they are so constructed as to answer this purpose exactly with the blood being brought to them, and so disposed in them as to go hand in hand."

THE PHYSIOLOGICAL EFFECTS OF MALDISTRIBUTION

The study to be described is largely concerned with those parts of the lungs where there is no circulation and, in consequence, where gaseous exchange cannot take place.

Towards the end of the last century, Zuntz (1882) realized that a portion of each inspiration achieved no more than the flushing of the respiratory air passages. The wasted part of the tidal volume became known as the dead space—or more specifically the anatomical dead space since its size is largely determined by anatomical considerations. In recent years, it has become apparent that, of the air which passes through the anatomical dead space to reach the alveoli, not all will necessarily take part in gas exchange. This is because some of the inspired air may enter alveoli

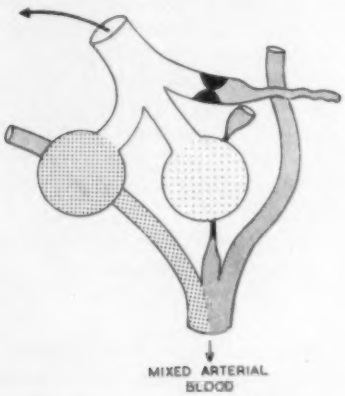

Fig. 1. Idealized diagram of three alveoli. The alveolus on the left is correctly ventilated and perfused. The alveolus in the centre is ventilated but not perfused. The alveolus on the right is perfused but not ventilated. (After Comroe, 1955.)

which have no circulation. The converse is also possible. Some part of the pulmonary blood flow can, and usually does, pass to alveoli without ventilation.

The effects of maldistribution are best explained with reference to Figure 1, in which are represented three alveoli. On the left is an alveolus which is correctly ventilated and perfused. In the centre is an alveolus which is ventilated but not perfused. (This might, for example, be caused by pulmonary embolus or by ligation of the pulmonary artery.) On the right is an alveolus which is perfused but not ventilated. (Such is the situation in any form of airway obstruction, atelectasis or consolidation.)

These two types of maldistribution cause quite different physiological effects. The unperfused alveolus in the middle makes no contribution to

the arterial blood and has virtually no effect upon its oxygenation. Nevertheless, it does mean that a portion of the inspired gas is wasted exactly as in the flushing of the anatomical dead space. Consequently it is known as the dead space effect and contributes to the physiological dead space—although not to the anatomical dead space which comprises solely the volume of the air passages. This effect may therefore be demonstrated by showing that the physiological dead space is appreciably in excess of the anatomical dead space, measured simultaneously. This approach has been used in the study to be described. The most important effect of the ventilation of unperfused alveoli is to reduce the effective alveolar ventilation and this results primarily in the retention of carbon dioxide.

The perfusion of unventilated alveoli, shown on the right, results in the admixture of venous blood with arterial blood. It is in fact a right-to-left shunt and, as in Fallot's tetralogy, the most important effect is desaturation of the arterial blood, the elimination of CO_2 being scarcely affected.

We had at least two reasons for considering that serious maldistribution might occur during thoracic surgery. Firstly, it had already been established that considerable ventilation of unperfused alveoli occurs during anaesthesia for surgery not involving the thorax (Campbell, Nunn and Peckett, 1958; Nunn and Hill, 1960). Secondly, there were reasons for considering that the open thorax itself would cause maldistribution (Dripps and Severinghaus, 1955). Indeed, a number of papers have already stressed the difficulty in obtaining adequate elimination of CO_2 during thoracic surgery. It has been suggested that high minute volumes of respiration are required for the maintenance of normal CO_2 tension during operations within the thorax (Lucas and Milne, 1955; Dobkin and Wyant, 1956). For this, maldistribution would be the only possible explanation. This was by no means an unreasonable suggestion, since most thoracotomies are performed in the lateral position.

Certain major readjustments occur when the lateral position is assumed. The lower lung receives more than its normal share of blood—probably for simple hydrostatic reasons (Fig. 2). It is, however, surprising to find that the lower lung also receives a proportionately greater share of the ventilation. This unexpected finding is explained by the fact that the viscera, and particularly the liver, force the dependent diaphragm higher into the chest on that side. The higher the diaphragm lies, the more efficiently it can contract and so the lower lung is both over-perfused and over-ventilated and its ventilation/perfusion ratio is thus maintained close to the normal value (Rothstein, Landis and Narodick, 1950).

Figure 3 represents a patient in the lateral position with an open thorax. The lower lung may still be expected to receive a greater pulmonary blood flow, but with artificial ventilation the high diaphragm confers no advant-

age. On the contrary, the lower lung carries the weight of the mediastinum and cannot expand as freely as the upper lung, which is freed of even the elastic recoil of the chest wall. One would therefore expect most of the blood to go to the lower lung and most of the air to the upper lung.

Thus it appeared very likely that there would be maldistribution during thoracic surgery. The primary purpose of this study was to determine whether the maldistribution was merely a physiological curiosity or whether it had clinical significance. Secondly, we hoped to quantify the maldistribution and to study the factors which influenced its magnitude.

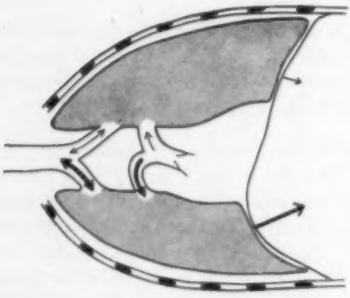

Fig. 2. Diagrammatic representation of ventilation and pulmonary blood flow in the lateral position.

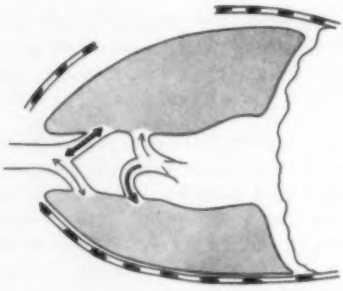

Fig. 3. Diagrammatic representation of ventilation and pulmonary blood flow in the lateral position with the upper pleural cavity opened.

The overall significance of the maldistribution was determined by measuring the ventilation and the arterial Pco_2 at the same time. A normal Pco_2 for the ventilation would indicate that such maldistribution as might exist was of little clinical significance so far as CO_2 was concerned. The quantification of the ventilation of unperfused alveoli was by simultaneous measurement of anatomical and physiological dead space. These measurements incidentally yielded data on the CO_2 output and on the arterial to end-tidal Pco_2 difference.

METHODS

A total of 14 patients were studied—six in the prone position, six in the lateral position and two supine. The last two were cooled to 29° C. for elective cardiac arrest for the repair of atrial septal defect, hypothermia being achieved by immersion in a bath of cold water (Table I). Only one patient had severe respiratory dysfunction. He was the eighth patient, and had emphysema incidental to carcinoma of the cardia.

TABLE I

DETAILS OF PATIENTS STUDIED

Initials	*Age*	*Sex*	*Cardio-Vascular State*	*Operation*
Prone				
E.V.	68	F	Normal	Hiatus hernia repair
D.A.	27	F	Minimal P.T.	Segmental resection
D.C.	21	M	Bronchiectasis	Lobectomy
W.H.	52	M	Pulmonary neop.	Thoracotomy only
B.B.	45	F	Pulmonary neop.	Lobectomy
G.G.	59	F	2ndry pul. neop.	Lobectomy
Lateral				
M.L.	60	F	Normal	Resection of neurofibroma
J.M.	57	M	Emphysema	Oesophago-gastrectomy
T.B.	65	M	Pulmonary neop.	Thoracotomy only
D.J.	16	M	Bronchiectasis	Lingulectomy
R.W.	14	M	Bronchiectasis	Segmental resections
V.K.	44	F	Mitral stenosis	Mitral valvotomy
Supine				
J.L.	10	M	A.S.D.	Closure
G.H.	11	F	A.S.D.	Closure

The patients were anaesthetized according to the methods in routine use by the anaesthetists responsible for their care. Pre-operatively, every patient received an opiate and a drying agent. Anaesthesia was then induced with thiopentone or buthalitone, and was maintained with nitrous oxide supplemented with pethidine or additional doses of thiopentone. No other inhalational agents were used, but relaxants were employed in all cases. A cuffed endotracheal tube was passed to a point approximately 5 cm. above the carina.

After induction, all patients were ventilated artificially at a uniform minute volume for about 40 minutes, by which time the chest had been open for approximately 15 minutes. Our measurements were then made over the following seven minutes—in the cases of atrial septal defect, this was immediately before elective cardiac arrest.

The first measurement was that of the anatomical dead space, carried out during three consecutive breaths. Next, arterial blood and expired gas were collected over a five-minute period for the determination of the physiological dead space. Finally, the measurement of the anatomical dead space was repeated over a further three breaths. Ventilation, CO_2 output and the arterial P_{CO_2} were obtained incidentally to the determination of the physiological dead space.

The measurements required the use of a specially designed apparatus for artificial ventilation of the patient (Fig. 4). During expiration of the previous breath, the motor-driven bellows were charged with the fresh anaesthetic gas mixture. This gas was then driven into the patient's lungs during the following inspiratory phase. This was then followed by

a passive expiration. Gas flow was directed by the Hill-Hook (1958) solenoid valve, which was synchronized with the bellows so that it should direct the flow of gas during inspiration and expiration. Each valve was controlled by a slugged relay so that it did not move until its fellow had come to rest in the closed position. In this way, there was complete separation of inspired and expired gas.

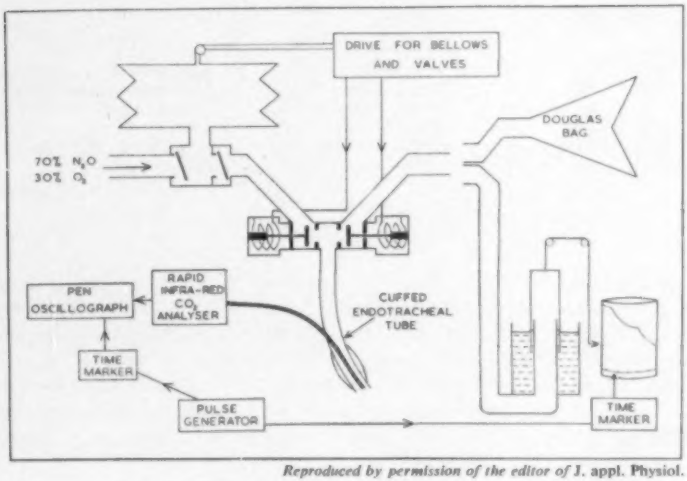

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Fig. 4. Gas circuit used for artificial ventilation.

Expired gas could be collected either in a Douglas bag or in a spirometer which filled stepwise over three or four breaths to give an expiratory spirogram. Gas was continuously sampled from the lower end of the endotracheal tube and passed through a Hartmann and Braun infra-red CO_2 analyser. The gas was then returned to the expiratory part of the circuit. The output of the CO_2 analyser was displayed on a pen oscillograph, which had a time marker synchronized with the one of the kymograph. Thus at any instant we could relate the CO_2 concentration of the breath to the volume exhaled.

The *anatomical dead space* was determined by the equal areas method of Fowler (1948) using CO_2 as the indicator gas (Bartels *et al.*, 1954). From the record of the spirometer and the CO_2 analyser, CO_2 concentration was plotted against volume expired—allowance being made for instrumental delay in the CO_2 analyser. The anatomical dead space was then calculated as the mean of the six breaths and this represented the anatomical dead space below the tip of the endotracheal tube.

The *physiological dead space* was determined by solution of the following form of Bohr's equation:

$$\text{Physiological dead space} = \text{tidal volume}\left(\frac{\text{Arterial } P_{CO_2} - \text{Mixed expired gas } P_{CO_2}}{\text{Arterial } P_{CO_2}}\right) - \text{apparatus dead space}$$

This gives that part of the tidal volume which does not participate in gas exchange. Tidal volume and mixed expired CO_2 concentration were obtained by measurement and analysis of the contents of the Douglas bag. Volume measurement was with a dry gas meter and analysis with a modified version of Haldane's apparatus (Nunn, 1958). The arterial P_{CO_2} was measured by the interpolation technique of Astrup (1956) using separated plasma, the pH being determined with a glass electrode whose output was increased potentiometrically. A previous publication (Nunn, 1959) has defined the accuracy of the method in our hands. Analysis of tonometer equilibrated blood revealed no significant systematic error and a random error of standard deviation 1.2 mm. Hg (uninfluenced by the presence of nitrous oxide). P_{CO_2} was measured at 38° C. and corrected for the patient's body temperature (Bradley, Stupfel and Severinghaus, 1956). Arterial blood was sampled from the aorta by the surgeons. The personal physiological dead space was determined from the result by subtraction of the apparatus dead space which was measured by water displacement.

The minute volume of respiration was determined by measurement of the contents of the Douglas bag collected during a known interval of time.

The CO_2 output was measured as the product of the minute volume and mixed expired CO_2 concentration—the appropriate corrections being made for the temperature and pressure at which the gas volumes were measured.

It was also possible to observe the difference between the arterial P_{CO_2} and that of the end-tidal or so-called alveolar air—the latter being indicated by the infra-red CO_2 analyser. For this purpose, it was necessary to measure the end-tidal P_{CO_2} with the maximum possible accuracy and allowance was made for the collision broadening effect of nitrous oxide (Ramwell, 1957).

Two patients were intubated with a Carlen's catheter which enabled us to determine the end-tidal P_{CO_2} from each lung separately. After measurement of the end-tidal P_{CO_2} of the mixed gas from the two lungs, solution of a mixing equation enabled us to determine the separate alveolar ventilation of each lung. Multiplied by the end-tidal CO_2 concentration this yielded the CO_2 output from each lung separately.

All gas volumes are reported corrected to body temperature and pressure, saturated with water vapour.

RESULTS

Anatomical dead space

Figure 5 shows the values obtained for the anatomical dead space (on the Y axis) plotted against the tidal volume (on the X axis). The open circles denote the lateral position and the closed the prone. No measurements were made in the supine position. Three points may be noted:

Firstly, the mean value for the anatomical dead space is about 60 ml.—rather less than half the normal value in the conscious subject. This reduction was, no doubt, due to the passage of the endo-tracheal tube which by-passed the mouth, pharynx and the trachea (Nunn, Campbell and Peckett, 1959). Secondly, the anatomical dead space increased slightly

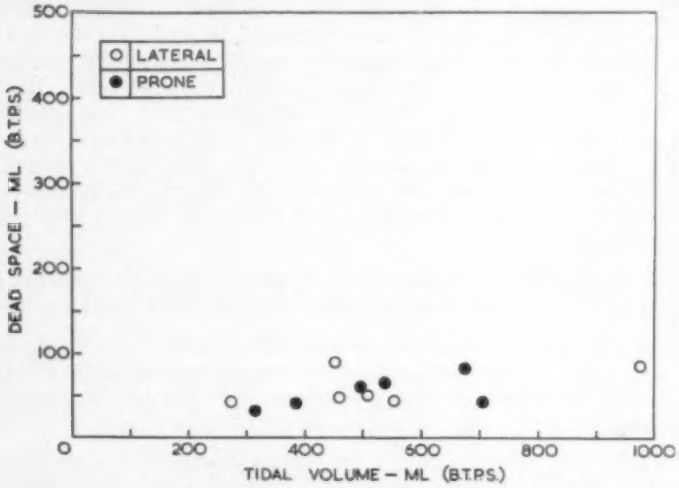

Fig. 5. Values for the anatomical dead space plotted against tidal volume.

with tidal volume, although this effect was too small to be of clinical significance. Thirdly, the position of the patient had no effect upon the size of the anatomical dead space.

Physiological dead space

Figure 6 shows the anatomical dead space as in Figure 5, but in addition is shown the simultaneous value for the physiological dead space which was invariably the larger. Observations on the same patient are joined by a vertical line. Again three points emerge:

Firstly, the physiological dead space was appreciably larger than the anatomical dead space, in contrast to the normal conscious subject in whom the two are identical. This is evidence of considerable ventilation

of underperfused lung. Secondly, the physiological dead space increased with the tidal volume and amounted to about one third of the tidal volume over the range of the observations. Thirdly, posture had no significant effect upon the physiological dead space expressed as a fraction of the tidal volume. One patient, in the lateral position, had an exceptionally large dead space for his tidal volume. This was the patient with emphysema—a disease which is known to cause an increase in the physiological dead space.

Figure 7 shows, along the Y axis, the dead space, expressed as a fraction of the tidal volume. Along the X axis is the fraction of the exposed lung which is expanded. This was estimated visually by the surgeon and was

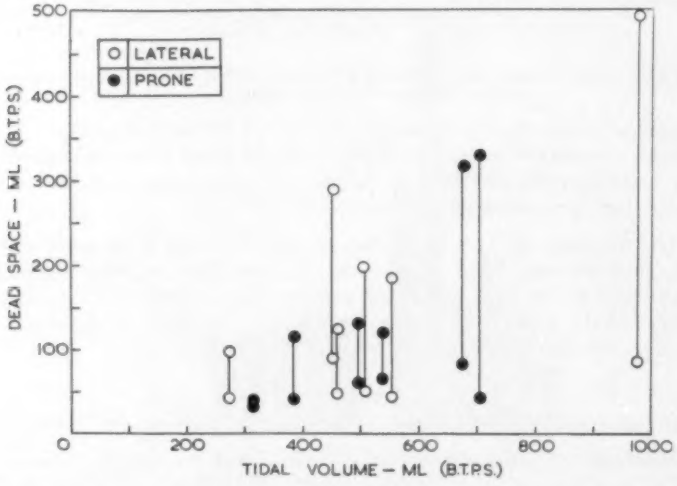

Fig. 6. Simultaneous values for anatomical and physiological dead spaces plotted against tidal volume.

largely a function of the lung retraction. The dead space tended to be larger when the exposed lung was fully expanded and this suggests that the bulk of the physiological dead space was in the exposed lung. Thus retraction of the lung was an important factor affecting the physiological dead space and probably overshadowed lesser factors such as posture.

Unilateral ventilation and perfusion

Table II shows the ventilation and CO_2 output for each lung in the two patients in the lateral position studied with a Carlen's catheter. In the first case, the upper lung was expanding freely and did in fact receive more than five times the alveolar ventilation of the lower lung and had three times its CO_2 output. In the second case, shown below, the exposed lung

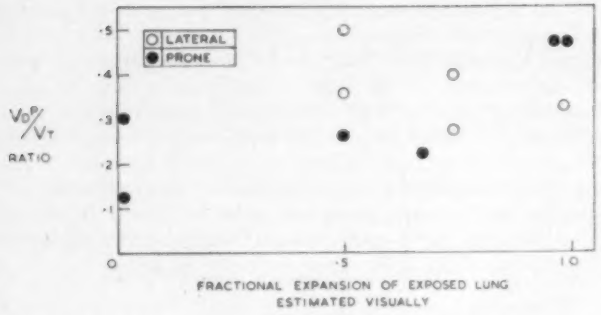

Fig. 7. Physiological dead space (as a fraction of tidal volume) plotted against expansion of exposed lung.

was retracted so that it occupied only half of the pleural cavity. It received a smaller alveolar ventilation than the lower lung and accounted for a considerably smaller CO_2 output. It is clear that retraction was a most important factor governing relative ventilation.

Unfortunately there were insufficient data to compute the relative perfusion of the two lungs. Nevertheless the ventilation equivalent for CO_2 (expressed as ml. CO_2 eliminated, per litre/min. alveolar ventilation) was higher in the lower lung in both instances. This suggests that the perfusion of the lower lung was in excess of that of the upper.

TABLE II

UNILATERAL ALVEOLAR VENTILATION, CO_2 OUTPUT AND VENTILATION EQUIVALENT

Expansion of exposed lung	*Alveolar ventilation l/m (BTPS)*		*CO_2 output ml/m (BTPS)*		*Ventilation equivalent for CO_2 –ml/l/m*	
	upper lung	*lower lung*	*upper lung*	*lower lung*	*upper lung*	*lower lung*
Full	6.1	1.2	183	56	30	47
Half	2.4	4.0	65	140	27	35

Arterial to end-tidal Pco_2 difference

In all cases the arterial Pco_2 was considerably higher than the end-tidal Pco_2 measured with the infra-red analyser (Fig. 8). The mean difference was 7 mm. Hg, but rather higher in the lateral than in the prone position. The very high value of 23 mm. Hg occurred in the patient with emphysema, which is known to cause a large arterial to end-tidal Pco_2 difference even in the conscious state.

The difference is an inevitable result of the ventilation of underperfused alveoli, and therefore it yields no further information on the nature of the

maldistribution. It is, however, important to know the magnitude of the difference if it is intended to monitor the CO_2 level of a patient by analysis of expired air.

CO_2 output

The mean CO_2 output of the normothermic patients was 14 per cent. below basal—being the same in the lateral and prone position. The two hypothermic patients had a mean output 40 per cent. below basal. The actual metabolic rate of the patients would be rather lower still as it is unlikely that equilibration of the body CO_2 stores had occurred in the time allowed.

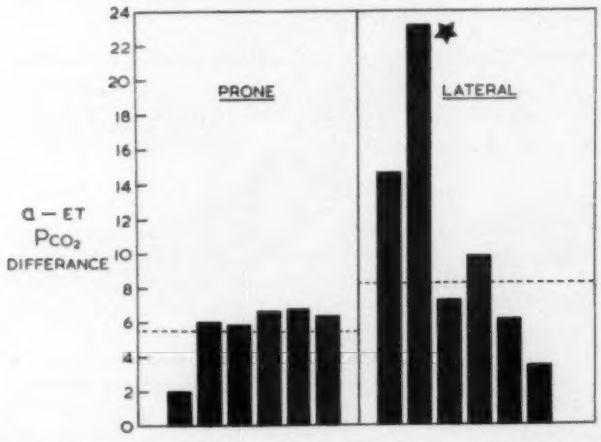

Fig. 8. Histogram of arterial to end-tidal P_{CO_2} difference. The star indicates the patient with emphysema.

Overall efficiency of ventilation

In spite of the defective distribution, in every case the arterial P_{CO_2} was within or below the normal range, with the exception of the one patient with emphysema.

Figure 9 shows the minute volume of ventilation along the X axis and the arterial P_{CO_2} along the Y axis. Arterial P_{CO_2} is inversely related to ventilation and the shaded band shows the relationship which has been found when fit patients are intubated and anaesthetized for operations outside the thorax (Nunn and Hill, 1960). The position of this band is, in fact, not greatly different from that in the conscious subject.

It will be seen that most of the results of the present study lie within the normal band and we may draw the conclusion that such maldistribution as exists is, from the clinical standpoint, no worse than when the chest is

closed. That is to say the open chest does not require that the ventilation be increased above the normal level in order to maintain CO_2 homeostasis.

The patient indicated by the star lies above the normal band. He was the patient with emphysema, a disease in which the ventilation is inefficient even when the patient is conscious. Nevertheless 46 mm. Hg is not so very high for emphysema and it is probably less than his customary P_{CO_2} when conscious.

The lowest tensions occurred in the hypothermic patients, the crosses indicating the patients who were deliberately cooled to 29° C. The patient in the prone position who lies well below the normal band did in fact have an oesophageal temperature of 34° C. She was not intentionally cooled, but the temperature fell spontaneously.

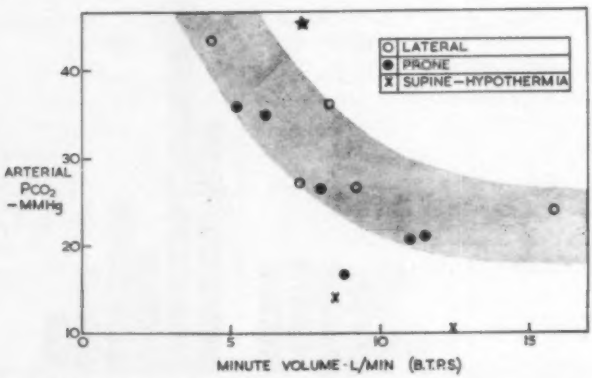

Fig. 9. Arterial P_{CO_2} plotted against minute volume of respiration. The shaded band indicates the relationship found in patients intubated and anaesthetized for extra-thoracic surgery (Nunn and Hill, 1960). The emphysematous patient is indicated by the star.

This diagram suggests that patients in the prone position tended to have a lower P_{CO_2} for their ventilation than those in the lateral position. This difference is not significant in so small a series.

Hypothermia

In two hypothermic patients there was certainly no difficulty in CO_2 elimination and, on the contrary, it was difficult to avoid depletion in the face of the great reduction in metabolic activity.

The values for the arterial P_{CO_2} of 14 and 10 mm. Hg corresponded respectively to pH values of 7.7 and 7.8—all values being corrected to the patient's body temperature. These figures reveal no evidence of metabolic acidosis at the time of sampling, which was immediately before elective cardiac arrest.

Anatomical dead space was not measured in the hypothermic patients, but the mean physiological dead space was 18 per cent. of the tidal volume. This indicates a higher efficiency of ventilation than occurs at normal body temperatures.

DISCUSSION

Clinically, the most significant finding of this study was that the overall efficiency of ventilation was as high during thoracic surgery as in the conscious subject. Therefore a normal ventilation was adequate for the maintenance of CO_2 homeostasis. The overall efficiency of the ventilation depends upon the summation of several factors which were altered by the conditions of thoracic surgery.

TABLE III

FACTORS AFFECTING ARTERIAL P_{CO_2} DURING THORACIC SURGERY

Raising P_{CO_2}		*Lowering P_{CO_2}*	
Alveolar dead space	+ 20%	Endotracheal intubation	− 18%
Apparatus dead space	+ 7%	Depressed metabolic rate	− 15%
Total effect	+ 28%	Total effect	− 30%

There appeared to be two factors tending to raise the P_{CO_2} and two which acted in the opposite direction (Table III). Tending to raise the P_{CO_2} was the ventilation of the underperfused alveoli (alveolar dead space). At an average minute volume, this factor would tend to raise the arterial P_{CO_2} by 20 per cent. Additional to this was the apparatus dead space which inevitably accompanies the use of any breathing circuit. With the circuit which has been described, this factor alone raised the P_{CO_2} by 7 per cent. and the summation of these two effects would raise the P_{CO_2} 28 per cent. higher than it would have been when the patient was conscious.

There were, however, two important factors tending to reduce the P_{CO_2}. Firstly, there was the endotracheal tube which by-passed about half of the air passages and so tended to lower the P_{CO_2} by 18 per cent. at the ventilation under consideration. Secondly, there was the reduction in metabolic activity which lowered the CO_2 output by 15 per cent. The summation of these two effects would lower the P_{CO_2} by 30 per cent. compared with the conscious basal subject. These factors lowering the P_{CO_2} were thus approximately equal and opposite to the factors tending to raise the P_{CO_2} and we may say a ventilation adequate for the conscious basal patient should also be correct for him when anaesthetized for thoracic surgery. In fact, Figure 9 suggests that a normal P_{CO_2} would be maintained by a mean ventilation of about 6 litres/minute—which is, if anything, rather less than the normal basal minute volume.

Overall, the conditions for the elimination of CO_2 during thoracic surgery were very similar to those which have been found during extra-

thoracic surgery, although there is no doubt that opening the pleura will usually disturb the ventilation/perfusion ratios of the two lungs. Retraction of the exposed lung deflects ventilation into the other lung, which in the lateral position is probably overperfused. Thus moderate retraction may improve the relative ventilation and perfusion of the two lungs and so increase the efficiency of ventilation. However, from the clinical standpoint of CO_2 elimination the advantage would appear to be negligible and, in addition, the retracted lung is in danger of atelectasis. CO_2 elimination presented no serious problem under any of the conditions pertaining during this study and therefore we would refrain from suggesting any modification of technique designed to improve CO_2 elimination.

It must be stressed that we have considered only the effect of maldistribution on CO_2 elimination. At the time of the study, we had no means of determining the effect of maldistribution on the oxygenation of the arterial blood. In particular, shunts through unventilated lung have a very marked effect upon the arterial oxygen saturation although little effect on CO_2 elimination. To the unaided eye, cyanosis is seldom a feature of anaesthesia for thoracic surgery in reasonably fit patients, but nevertheless it is hoped in the future to carry out a study designed to determine whether maldistribution offers any serious obstacle to oxygenation during thoracic surgery.

CO_2 retention was very easily avoided during this study. However, it would be wrong to extrapolate to other conditions and, indeed, it is well established that fatal CO_2 retention may occur in connection with thoracic surgery.

Without doubt, the most important cause of these disasters is inadequate ventilation. In some parts of the world, it is still customary to allow patients to breathe spontaneously with the chest open, which results, not only in frank underventilation, but in pendulum breathing between the two lungs. Still more dangerous is the immediate post-operative period, when the patient is faced with the re-establishment of spontaneous respiration—perhaps in the face of considerable reduction in functioning lung tissue. In addition there may well be residual narcosis and myoneural blockade as well as the encumbrance of dressings and a drainage tube. If, as frequently is the case, the remaining lung tissue is diseased, there is a real danger of ventilatory inadequacy leading to CO_2 retention. The risk appears highest in bilateral tuberculosis and in emphysema concomitant with carcinoma of the lung.

There is a second factor which was deliberately excluded from the present study. Certain anaesthetic gas circuits may return CO_2 to be reinhaled by the patient. Under these conditions, the arterial P_{CO_2} may be raised to almost any level (Schultz *et al.*, 1960). This has certainly caused serious CO_2 retention in the past, but the principles of efficient circuit design are now well understood and CO_2 retention from rebreathing should no longer occur.

SUMMARY

In summary, then, 14 patients have been studied during anaesthesia for routine thoracic surgery. In every case there was maldistribution as shown by the physiological dead space being considerably in excess of the anatomical. This was confirmed by demonstrating the arterial Pco_2 to be in excess of that of the end-tidal gas. The exposed lung was found to be preferentially ventilated if allowed to expand freely, but this effect could be reversed by retraction. Although the maldistribution would tend to raise the Pco_2, the use of an endotracheal tube and the depression of CO_2 output had the opposite effect. Overall it was found that a normal arterial Pco_2 could be maintained by a minute volume of ventilation close to the normal for the conscious resting subject.

ACKNOWLEDGMENTS

I am deeply indebted to Mr. T. Holmes Sellors, Dr. A. Parry Brown and other members of the staff of Harefield Hospital for permission to study patients under their care, and for their active co-operation during the study. Apparatus was constructed and adapted by Mr. J. Hook and gas analysis was carried out by Miss T. C. Guilfoyle. Maintenance and operation of electronic apparatus was in the charge of Mr. D. W. Hill.

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JOHN HUNTER — ORDER OUT OF VARIETY

Arnott Demonstration at the Royal College of Surgeons of England
on
28th October 1959
by

D. Greer Walker, M.D., M.D.Sc., F.D.S.R.C.S.
Middlesex Hospital, Stoke Mandeville Hospital and
Royal Dental Hospital

UNDER THE ARNOTT TRUST provision is made for discourses on specimens contained in the Hunterian Collection. When I was invited to give this lecture-demonstration, my first reaction was one of mixed feelings. In the first place I regarded it as a great privilege, and, furthermore, I thought it was my duty to accept since I have received much kind help in the past from Professor Causey's department, where the Hunterian Collection is kept. My misgivings about such a lecture naturally stem from the fact that I can in no way claim to be an authority on the work of John Hunter. I have, however, in the course of my work over the past few years had occasion to refer to certain aspects of John Hunter's work. One very soon obtains the impression that the Hunterian Collection is no mere magpie assortment, and the reason for the institution of an Arnott lecture-demonstration becomes very obvious.

I have often been told that I bury myself in Museums, the Hunterian and the Odontological in this College, the sister College in Edinburgh, the Natural History Museum, and many others. Such remarks come from those who never visit museums, and who, for some reason or another, regard museums as only of historical interest. That may be so to a point, but on deeper reflection I have found museums one of the most exciting and stimulating centres for thought. Perhaps I may be able to convey to you to-day this impression.

Before we enter the Hunterian Museum I should like to place John Hunter in relation to the scientific background both before, and during, his lifetime. This will be an extremely brief account, but it is essential to have certain landmarks.

Vesalius (1514–64), the Father of Modern Anatomy, had introduced his new methods at Padua. This was the beginning of the breakaway from Galen. Another landmark is Harvey (1578–1657), who had dispelled the ancient belief of Galen's "spirits" and substituted his own scientific explanation of the circulation. Harvey studied at Padua in the year 1597, one year after the birth of René Descartes (1596–1650). Professor Singer (1950) in his well-known work on the Historical Aspects of Biology has stated that: "It has been convenient to treat Harvey's work as the last flower of Renaissance biology rather than the first of modern times". Singer, in common with other historians, also regarded Descartes as the herald of a new era of science.

To appreciate the implication of the latter remark we must give the substance of Descartes' views on scientific method. Professor Singer has stated that Descartes resolved:

"(*a*) Never to accept anything as true which I do not clearly know to be such, avoiding precipitancy and prejudice and comprising nothing more in my judgment than is absolutely clear and distinct in my mind.

(*b*) To divide each difficulty under examination into as many parts as possible.

(*c*) To proceed in my thoughts always from the simplest and easiest to the more complex, assigning in thought a certain order even to those objects which in their nature do not stand in a relation of antecedence and sequence—i.e. to seek relation everywhere.

(*d*) To make enumerations so complete and reviews so general that I might be assured that nothing was omitted."

The significance of our remarks so far can be very briefly summed up when we say that there was a split in the scientific method appearing on the horizon. The split was further complicated by the fact that the philosophers and theologians still held considerable sway and this, needless to say, led to greater separation. Stated in its simplest form, Harvey and John Hunter among others were labelled by historians as vitalists and thereby separated from the scientists described as the mechanists or materialists. The dichotomy that is alleged to have arisen in science about this period has been to some extent a confused story. The heavy weather that has been made between the vitalists and the materialists is of no great concern to us at the moment. But let us remember that there are, and always will be, separate approaches in science and of necessity a certain amount of exactness and also some inexactitude. The one approach we might describe as biological, a study of life that in certain respects does not readily lend itself to any exact discipline. The other, the precision of mathematics and chemistry which can be applied with great value to other aspects of biology. It stands to reason that the methods will differ and we must resign ourselves to accepting diverse ways and means otherwise our progress will suffer.

The deductive teaching of Aristotle had been the accepted arrangement of the animal kingdom up to the end of the 17th century. There is no doubt that attempts were being made before this time to suggest certain changes, but it is convenient to take the year 1693 as one where definitely the old order was changing for the new inductive approach. This is the date of John Ray's publication of his suggested changes in animal classification, and it occurred 35 years before Hunter was born, a fact which it is extremely important to bear in mind.

To complete our chronology let me remind you of some of the genius surrounding John Hunter (1728–93) in this glorious 18th century: Buffon (1707–88), Linnaeus (1707–78), Bonnett (1720–93), Erasmus Darwin (1731–1802), Lamarck (1744–1829), and Cuvier (1769–1832). The connecting link with the subsequent century is Richard Owen (1804–92), who

was for some time in charge of the Hunterian Museum and later Director of the Natural History section of the British Museum.

This list of names is too well known to need elaboration and it is sufficient to say if comparison is made between John Ray's classification of animals and that of Cuvier—separated by a matter of about 100 years—we can picture the tremendous progress that took place in Hunter's time.

We should be well advised in attempting to establish " order out of variety " to begin by examining two specimens out of John Hunter's collection. I think you will agree, when we have discussed both of these

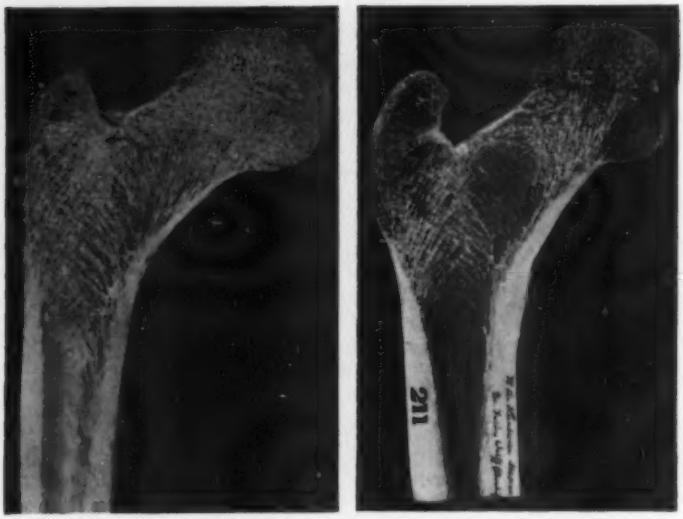

Fig. 1. (*a*) Hunter's specimen of the neck of the femur demonstrating the internal architecture of the bone. (*b*) The specimen sent to the Hunterian Museum by Wolff.

specimens, that John Hunter was oblivious to speculative science and made good use of the biological approach, but not to the complete exclusion of mechanistic methods.

The first Hunterian specimen (No. 208; Fig. 1 (*a*)) is the engineers' paradise and you will, I am sure, marvel with me at this beautiful specimen demonstrating the trabecular arrangement of the internal architecture of the femoral bone. There is no need for me to remind you of the long story of bone mechanics which began after Hunter's time. In 1867 Von Meyer and his engineer associate Culmann put forward their views on the mechanical principles involving bone structure. This was preceded by

others, but the mechanical principles were more in the nature of suggestions. Miss Jessie Dobson (1949), our present Curator of the Hunterian Museum, has reminded us of Frederick Oldfield Ward's comparison between the femoral neck and the Victorian lamp-post. This was in the year 1838. We cannot be sure of Hunter's observations regarding the trabecular arrangement, but we must remember that his morphology was only considered in relation to the function of the part. Richard Owen records the following remarks against this specimen in the year 1853: " . . . The columnar cancelli are arranged in dissecting curves, like the arches of Gothic architecture, where they transfer the weight sustained by the head and neck of the bone upon the strong and compact shaft: . . . " It is perhaps very fitting that we should compare this specimen with one sent by Wolff (No. 211, Fig. 1 (*b*)). Sir Arthur Keith, a late Conservator of the Museum, stated the contents of Wolff's law in the following simple language: " A bone has the power to adapt itself to the burden it has to bear." Over 100 years lie between the preparation of these two specimens. One is compelled to add that Hunter, among his many activities, could never be classed as an engineer; but equally so one is compelled to add that in his study of bone he sought elucidation from every angle.

In striking contrast let us take another specimen (No. A105) and this time consider John Hunter's work on bone growth investigated experimentally by madder feeding. Belchier in 1736, during Hunter's lifetime, was responsible for madder feeding. The madder produced a red pigment which demonstrated the points of activity in growing bone. Hunter was able to prove to his own satisfaction that there was external deposition in the growing long bone and absorption of the inner or medullary cavity wall. Those interested in the development of the mandible will recall the work of the late Professor Brash (1924) which was published as a series of lectures by the Dental Board of the United Kingdom.

The above specimens demonstrate two very different approaches to the study of bone form, and if we are to bring the matter up-to-date we should compare the wonderful study on " Growth and Form " carried out by Professor D'Arcy Wentworth Thompson (1942) with the recent advances in tissue culture and the transplantation of embryonic tissues. Time does not permit of any elaboration of Professor Thompson's contribution on the growth intensity of the body as a whole and distributed according to an orderly system of growth gradients; and we are unable to pursue the pioneer work of Murray and Huxley (1925), Strangeways and Fell (1926) and others on embryonic tissue culture and bring this study up-to-date. Further scientific advancement must be sought from every angle; no one method is complete in itself.

There is a short and valuable account of the Hunterian Museum written by Miss Dobson (1958) and if you turn to page 5 you will find that Hunter,

while on army service in Portugal, was collecting the beginnings of his Museum. Among his diversions as an army doctor in the Iberian peninsula he examined lizards. The book in question states that the regeneration of lizards' tails and many other problems formed some of his preoccupations. Further on there is the following note: " Specimen 2859 : 91 (Fig. 2) shows a lizard in which the new tail when nearing its completion was again broken off and regenerated. The tail thus consists of three parts: the stump of the original tail; the first new growth covered with scales different in form from those of the stump; and the second new growth, without scales, smooth, soft and tender." The account by Miss Dobson tells that this specimen was brought back by Hunter from Portugal. We could spend a lot of time discussing this interesting phenomenon.

Fig. 2. Hunterian specimen showing the regeneration of the tail in a lizard.

Professor Lacroix (1951) of the University of Louvain is well-known for his work on bone, and in his book *The Organization of Bones* you will find details of an experiment carried out by Hellstadius which was repeated by Lacroix. There is a picture of the ulna of a two-month-old rabbit showing the extent of the distal third that had been excised extra-periosteally. The figure beneath shows the regeneration of bone two months later and the comment is as follows: " The stump of the ulna diaphysis has gradually elongated thanks to the reconstitution of a growth cartilage, whose situation is indicated by an arrow." John Hunter returned from army service in 1763, Hellstadius published his work in 1945, and Professor Lacroix's work was published in 1951.

Hunter's specimen of the lizard's tail opens up a vast field of study into the reaction of the tissues to both disease and trauma. It is not my intention to enter on an elaborate discourse, but I should like to place before you brief details of four interesting cases all bearing on this interesting topic of tissue repair. I was much impressed by a simple experiment on a child who was sent to me on account of a dentigerous cyst of the mandible. The tooth contained in the cyst and the adjacent teeth were displaced out of normal alignment in their unerupted position in the jaw. Their depth of

submergence was increased by the cyst. I treated the cyst after the simple fashion of removing the oral mucosa with the cyst lining that occupied the position on the alveolar ridge. Subsequently all the teeth erupted and with a little orthodontic assistance were guided into their normal position. The process of eruption that had been temporarily suspended was able to resume when the offending cyst was treated.

Another case demonstrating the movement of teeth was a case of unilateral arrested mandibular growth under the care of Mr. R. P. Osborne and myself. As the result of a middle ear infection the cartilage growth in the mandibular condyle ceased and this resulted in the typical shortening of ramus length. In such cases the molar teeth remain in the ramus and are unable to migrate forwards and erupt into occlusion. We lengthened the ramus by means of an interstitial bone graft. The third molar tooth which was not developed at the time of operation was found distal to our bone graft developing normally a few years later. In the course of time this tooth migrated through the bone graft and erupted into its correct position.

It is important that every effort should be made to understand this phenomenon of repair, and another example provides us with some valuable information. The case was referred to Mr. R. P. Osborne on account of an extensive adamantinoma involving the right side of the jaw. The treatment was excision of the affected half of the jaw and reconstruction by a bone graft. The bone graft consisted of a series of chips threaded on a Kirschner wire which was secured to the symphyseal portion of the jaw. The bony union of the graft demonstrated two valuable points. No host periosteum remains and the " chips " all united one to another leading one to conclude that bone is not dependent on the periosteum of the part for bony union. The second point is something of a contrast to the first; in the absence of host periosteum there has been no suggestion of a re-formation of a mandibular shape.

The fourth case was under the care of Mr. J. P. Reidy, and was a rather severe manifestation of the Treacher Collins syndrome. In such cases the mandibular growth can be severely curtailed resulting in the marked receding chin. In these cases the body of the mandible is bent so that the convexity faces the upper maxillary teeth. Mr. Reidy fractured the jaw on both sides in the region of the mental nerve exit from the bone. When the body was straightened the gaps at the lower border were filled with chip bone grafts. The result of this was to place the chin in a vertical position. The bending of bone is a phenomenon frequently seen and it does not raise the problems that are associated with interference to the external contour of bone which is under the strict control of the periosteum. I have discussed these cases at fuller length in another publication (1958).

I have briefly mentioned these experimental cases to demonstrate a field of study that appealed to John Hunter. What began with the lizard's tail is now a very formidable branch of biology.

We must now return to another of Hunter's specimens (No. H64; Fig. 3), a series of mandibles arranged according to age, to demonstrate that the mandible grows from the posterior end. Hunter was proved to be correct and of course nowadays we can explain why he was right. The growth of the mandible is from two sources—the length is obtained from the epiphyseal cartilage in the condyloid process and the thickness from the

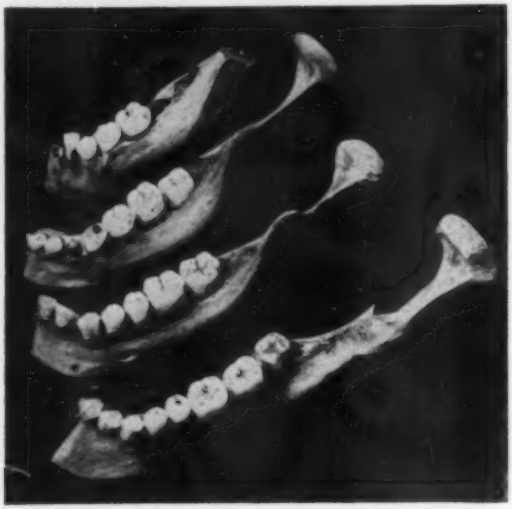

Fig. 3. Hunter's series of mandibles to illustrate the growth in the posterior portion.

local appositional periosteal bone growth. We can very easily prove that the condylar cartilage lengthens the jaw; all that is needed in animal experimental work is to destroy this growth centre. But this is unnecessary for we can select a series of cases, ante- and post-natal, that will satisfactorily answer our question. For example middle ear infection, trauma, and infection of the jaw have been the agents responsible for some form or another of agenesis of the condylar cartilage in children. In my collection of such cases, which includes a liberal supply from Professor Kilner, I have been able to study the effects of growth disturbance in the mandible of all ages. John Hunter was quite aware of the phases of growth as distinct from the phases of development. He carefully exposed the teeth in the jaws of a six-year-old child (No. H135; Fig. 4) and he certainly was not uninterested in embryology when he hung in his museum two pictures

(Nos. 49 and 50) painted by Rymsdyk demonstrating the developing chick in its shell. Without expatiating on the matter we can conclude that all this early work has led on, among other things, to a better understanding of the hazards of pregnancy. The work of the late Dr. George Streeter (1942) is an example. He regarded the embryo as a series of horizons; and malformations could be related to or dated by a particular horizon.

John Hunter did not confine his interests to detail, so I now propose to turn to a more general problem and select for discussion our segregation

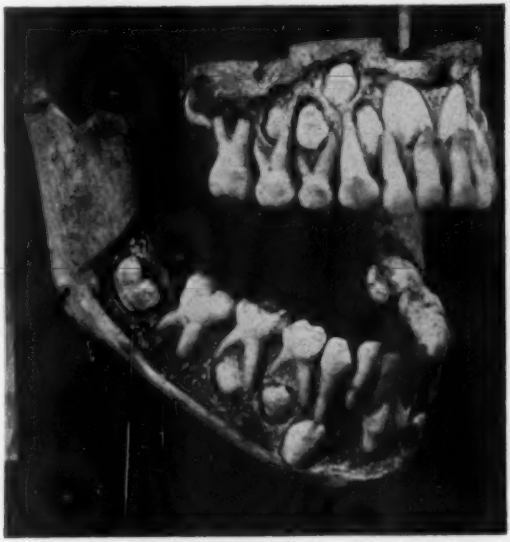

Fig. 4. Hunter's dissection of the teeth in a child of six years of age to demonstrate the stage of development reached at this period.

of the normal from the abnormal. Teratology has been the term applied to the study of monsters. It has been said that Geoffroy St. Hilaire was responsible for this terminology, but this was subsequent to Hunter's lifetime. We shall select from Hunter's work his observations on " Progression and Declension of Perfection in Animals ". Hunter expressed an interest in the normal and the abnormal or monstrous forms. In fact the following quotation from his work very clearly demonstrates Hunter's enquiring mind. It is as follows: " What we call ' perfection ' in animals does not increase in regular progression in every part, but as animals are complicated; and each complication has its degree of perfection. These degrees do not correspond in perfection; (they are not) regularly progressive in every part from the most imperfect to the most perfect

(animals) although they go in pretty regular steps of perfection among themselves. Thus Fish are an inferior order of beings to Fowl; yet Fish have teeth, a property belonging to the highest order; therefore Fish in this part step over Fowl. The Amphibia, which are between Fish and Fowl, in this respect resemble both, having both teeth and bill; but they are most like the Fish." There were three specimens to illustrate Hunter's dilemma—Lizard (386) with teeth, Tortoise (2105) with bill, and Siren (1063) with both; unfortunately the Siren is all that remains.

The theme of " perfection " is still with us to-day, and the introduction of the terms normal and abnormal have helped to maintain this ancient Hellenic philosophy. Hunter had given considerable thought to monstrosities and we find him dividing them into duplications, deficiencies and " bad formations ". There is no doubt in my mind that Hunter was confused about the issue of perfection since some creatures manifested what could truly be likened to monstrous formations. Historically the mythology that has encompassed monstrosities can be accurately dated from Chaldean records, where we can find evidence of these monstrous forms depicted as being good omens or as presaging some disaster. There is also the complicated ancient belief in the inter-animal element compounds and all these beliefs lie on the other side of the fence to the ideology of perfection. The ancient division between the perfect and the monstrous is maintained even to-day. Teratology, the ill-begotten child of embryology, has become the foster child of pathology and certainly the unwanted child of science which is unwilling to find any place for it in our evolutionary history.

It is remarkable how monstrous formations in certain creatures have been regarded as the height of perfection, so much so that the abnormal part has become the distinguishing feature that has been selected as an example of the end stages of a long phylogenetic history. The most remarkable case of this sort is the horse's single digit. Mr. T. J. S. Patterson (1959) delivered a Hunterian lecture on 200 cases of limb malformations, a series of cases collected from St. Thomas's Hospital and Great Ormond Street Hospital for Children. The case I wish to mention out of this collection was one under the care of Mr. (now Sir) Denis Browne, a child with a single digit on both forelimbs. I shall confine myself to remarking that such a malformation can be produced in one generation whereas the horse's single digit is stretched over some fifty million years. The story of the horse has been told too often to bear repetition. I therefore thought that I would select a less popular subject for discussion.

The birds are divided into two great groups according to the form of the sternum. I expect most of us have had the opportunity at some time or another of examining the carina in the bird family. This is the term

applied to the keel-like structure on the anterior aspect of the sternum, which affords attachment for the pectoralis muscle. Unless the particular carver of the Sunday meal has had a special interest in this portion of avian anatomy he may have neglected to compare the undue prominence of the carina in the birds of flight, the carinates, with the reduction of this structure in the flightless, or the ratite birds. You will find in the Museum Hunter's specimen of the Great Auk (1605; Fig. 5) and other non-Hun-

Fig. 5. Hunter's specimen of the Great Auk.

terian specimens such as the Solitare and the Dodo all showing variations in this part of their anatomy. The form of the forelimbs in these creatures shows an equal degree of variation in perfection. Similar malformations are described in *Homo sapiens* under the teratological group of amelia. In fact some of the conditions, as for example phocomelia, are named on account of their resemblance to structures in other animals (in this case, in the seal). The birds are not the only creatures to have these malformations classified under the perfect structures.

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The group of aquatic carnivorous animals presents us with a most interesting range of limb structures, all of which in any other beast would come under the group of malformations. There is an excellent book by Dr. Swinton (1958), a British Museum publication, titled *Fossil Birds*. If comparison is made between *Hesperornis regalis* and *Ichthyornis victor* it will be evident that at this early stage in bird evolution there are marked differences in some of the forelimb structures. The digits of certain mammals, the limb structures of the aquatic carnivora, and the forelimbs of the birds can be explained on a disuse hypothesis or they can be accounted for as an abrupt change in the nature of a mutation.

There remains on this subject of limb forms the rather peculiar association of absence of the pectoralis muscle in certain cases. Mr. Patterson (1959) has kindly given me the following note:

" In congenital absence of muscle, the pectoralis major is most frequently affected (Adams, Denny-Brown and Pearson, 1953). As an isolated deformity it is usually the costal heads of origin which are missing—rarely the whole muscle. Approximately 25 per cent. of these cases have an abnormality of the upper limb on the same side; either a general diminution in size or a deformity of the hand only (Brown and McDowall, 1940). It is interesting that the hand deformities are nearly always of the same type—the small webbed hand or, less commonly, the lobster-claw. All other types of hand deformity have normal chest development, except some cases of gross agenesis and radial club-hand, often bilateral, where the shoulder is severely affected, and the pectoralis is only one of several missing or anomalous muscles.

" In 24 consecutive cases of small webbed hand in this series, there were 12 with absence of the costal heads of pectoralis major, and in 17 cases of lobster-claw, three with absence. The deformity of the chest was always on the same side as the hand deformity. All the girls who had a hand deformity and absence of the pectoralis major had under-development of the breast of that side."

There is a well-known book on *Dental Anatomy*, originally compiled by Sir Charles Tomes in the year 1876. The eighth edition was produced in 1923, edited by Dr. Marett Tims and Mr. Bowdler Henry. I have taken the following passage from page 251:

" But there are some correlations of growth of a still more recondite nature, in which the connection is less obvious. Of this kind is the relation which exists between peculiarities of the skin and of the teeth: the Edentate, abnormal in their skins, are different from most other Mammalia in their teeth; whales, yet more aberrant in the nature of their skins, have only rudimentary teeth, in place of which, after birth, plates of whalebone are found.

"Darwin has collected a number of curious instances of relations existing between hair and teeth. In general terms it may be said that any great abnormality in the hair goes hand-in-hand with an abnormality of the teeth. Thus there is a breed of dogs found in Turkey which is almost hairless, and which has very few teeth, the dentition being reduced to a single molar on each side, together with a few imperfect incisors; in the human subject inherited baldness has been often found to be associated with inherited deficiency of the teeth; on the other hand, redundance of hair has in several cases been accompanied by absence of teeth."

This so-called correlation is nothing more than ectodermal dysplasia; and I am suggesting that these malformations in the light of modern advances cannot be lightly dismissed as having no part at all in the evolving of the animal kingdom.

The fascinating postulation exists that if the birds are segregated according to the normal and the abnormal sternum, and similarly the digital structures separate certain mammals, may not the future segregation of the human type be possibly based upon jaw relationship? A recent survey of the population in a part of this country by Mr. Phillip Walther (1959) of the Royal Dental Hospital showed that the dental occlusion was as follows: normal occlusion 53 per cent., micrognathic occlusion 39 per cent., and prognathic occlusion 8 per cent. Our standards of population normality will soon need some overhauling. It appears on the available evidence that in the foreseeable future the human facial form may develop more diverse distinguishing features and stand out in greater contrast to the so-called model of perfection. In such an event, the changes in the jaws may follow the phylogenetic story of the sternum and the digit.

I think we must enquire if in the treatment of our patients there is any real advantage to be gained by continuing the segregation of the normal from the abnormal or monstrous forms. Our study must surely be one to establish order out of the widest variety. Any survey of the population will show that while the infectious diseases in children are on the wane there are many deviations from the normal in one form or another on the increase. For some rather obscure reason the awakened interest in experimental teratology to-day has not been sufficient stimulus for those expressing some clinical interest in the cranio-facial structures to realize that this is one of our present problems. Mr. R. P. Osborne (1959) informs me that the Lancashire statistics showed that in 1941, in common with other figures elsewhere, cleft lip and palate cases occurred at the rate of 1 : 1000. Recent figures from the maternity services of Liverpool show that in 1959 the rate is 1 : 700. We must consider the normal and the abnormal as a population group, and in our work include a wide variety of differing forms ranging from the simple unerupted or absent tooth to the

more marked environmental and genetic hazards affecting the face. It is only by this means that our understanding will be increased.

The future of man's face is dependent upon two separate factors. The first is the commonly expressed view that man's face with its phylogenetic history demonstrates recession of the snout; the face has become more vertical and is now tending to present a concave appearance. The second factor concerns the more immediate disturbance of environment and the possible hazards of heritage arising from life of increasing domestication where advances in science lead to a better expectation of life and thereby to perpetuation of certain malformed types. The agencies at work in our evolutionary history appear to demonstrate that the modern face is still in the process of reduction. It may be that this is the sole factor responsible for our small jaws crowded with teeth. It seems this is the obvious way to explain the everyday occurrence of the unerupted third molar teeth. In contrast the more short-term episodes can account for the marked retrusion of the middle third of the face, for the missing lateral incisor teeth, for the micrognathic jaw, and so forth. It is possible that these short-term happenings in their wide variety, which can be witnessed more accurately since they are sudden and abrupt changes, may eventually be incorporated or rejected in our future phylogeny depending upon their transmission and other circumstances.

Finally, in our attempt to grasp the implication of these problems, we must surely look back upon John Hunter and admire his variety of interest. To-day, with our increasing specialization and the consequent narrowing of our vision we must be careful that we do not become too isolated from work and events outside the restricted range of any particular specialty. Perhaps I could illustrate this with one example, a comparison between two cases. The one condition described by Professor Robert Scarff and myself (1948) is now placed in the group of fibrous dysplastic lesions. The particular condition that we discussed was originally described by Westmacott in 1913 as hyperplasia of the maxilla. The other is a case that Dr. Dermod MacCarthy asked me to see, an infant with considerable underdevelopment of the left maxillary process. In two rather dissimilar clinical conditions one is forced to enquire where does embryology end and pathology begin. This has been brought home to us recently in Professor Willis's (1959) book on *The Borderland of Embryology and Pathology*. While specialization must go on, let us follow John Hunter in establishing order out of variety, bearing in mind the greater the variety the greater the order thereof.

John Hunter expressed the opinion that malformations were more common in domesticated animals. To-day opinion has not changed. To illustrate Hunter's statement I should like to give to the Museum two specimens: one a domesticated prognathic trout caught in "stocked" water in Buckinghamshire, and the other an undomesticated mackerel caught in the Atlantic off the West Coast of Ireland showing a malform-

ation of spine. Malformations occur in all forms of animal life, but the chances of survival are increased with domestication.

Sir Arthur Keith collected a wonderful number of specimens demonstrating severe malformations of the face. Unfortunately most of this material was destroyed when the Royal College of Surgeons was damaged during the last war. On behalf of Mr. C. P. Wilson, I should like to give to the collection of teratology a malformation of the nose. This specimen is from the Ferens Institute of Otolaryngology at the Middlesex Hospital.

I am indebted to a number of colleagues, mentioned in this lecture, for the use of their material. Professor Causey's department has offered me every facility and I am particularly grateful to Miss Jessie Dobson for her valuable assistance. In Professor Cunningham's department, Dr. Proger has kindly helped me to trace some teratological material.

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ANATOMICAL MUSEUM

THE SPECIAL DISPLAY for the month of April consists of a group of photographs of John Hunter's friends.

THE COLLEGE AND THE 1961 PHYSICAL SOCIETY'S EXHIBITION

by

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THIS YEAR THE College was represented, for the first time, at the Physical Society's Exhibition. This is the leading instrument exhibition of the year and comprised 146 stands drawn from industry, government scientific establishments and the universities. It is held in the Royal Horticultural Society's Halls in Westminster.

Three exhibits from the Research Department of Anaesthetics were shown. These comprised a servo controlled pump for the generation of respiratory waveforms, a minute volume recorder and a gas chromatograph for the analysis of anaesthetic gases and vapours.

Servo controlled pump

In laboratories concerned with the development and testing of breathing equipment there is a need for a versatile breathing machine. To this end the servo pump has been designed to be as versatile as possible. It is an improved version of that shown at the Third International Conference on Medical Electronics (Hill, 1960b) and a full technical description will shortly be published in the *Journal of Scientific Instruments*.

The pump consists basically of two perspex pistons driven from a Velodyne motor speed control. The pistons are each driven via a linkage designed so that the stroke of either may be easily adjusted whilst the

pump is running. Contra-pistons are fitted so that the residual volume above top dead centre may be adjusted.

The Velodyne speed control circuit is a system for ensuring that the speed of the electric motor is accurately proportional to an applied voltage. If the voltage is made to vary with time, then the pistons will trace out the desired breathing pattern. The varying voltage is derived from a perspex function generating disk coupled to the driving shaft for the piston connecting rods. A radial beam of light scans the disk and then falls onto a photocell, the electrical output from which is fed into the speed control circuit. The disk is originally covered with an opaque material. Parts of this are then removed so that the light transmitted to the photocell, and hence the speed of the pistons at any instant, varies with the rotation of the disk. With this system it is easy to construct new disks for different waveforms and there is the minimum of mechanical wear. The data for constructing a disk are originally taken from a pneumotachogram.

An electronic variable delay unit is incorporated so that a post-expiratory pause of variable duration may be introduced. The pump was constructed jointly by Mr. Hook and Mr. Mable in the Department's workshops.

Minute volume recorder

This is a device for providing a written record of the minute volume of a patient and the original design was by Professor Woolmer and Mr. Hook. The expirate is passed into a conventional dry gas meter and the output spindle of the meter drives a leadscrew carrying a wheel. The rim of this wheel is in contact with the surface of a cone which is rotated at a constant speed by a synchronous electric motor. The axes of the cone and leadscrew are so orientated that as the wheel travels from one end of the leadscrew to the other it moves from the apex to the base of the rotating cone, and is thus rotated at an increasing speed. The constant rotation of the cone causes the wheel to travel along the leadscrew in one direction; intermittent rotation of the leadscrew, with each expiration, causes it to travel along the leadscrew in the other direction. The wheel thus hunts about a point whose distance from the end of the leadscrew is proportional to the rate of ventilation. A pen coupled to the wheel records this value on a moving strip chart. The amount of hunting is a function of the rate and depth of respiration, and can be reduced to negligible proportions by the choice of a suitable time constant. The meter thus provides the investigator with a record of the rate of ventilation, in terms of litres per minute, and enables changes in this value to be correlated with the action of drugs or other factors which influence respiration. The original meter produced in the workshop of the Research Department of Anaesthetics was shown together with a production prototype produced by British Oxygen Cases Ltd.

Anaesthetic gas chromatograph

As mentioned previously in the *Annals* (Hill, 1960a), it is possible by means of gas chromatography to analyse the gases and vapours encountered in anaesthetic studies on one apparatus. The method is not sufficiently fast to analyse for a single breath, but is very useful for monitoring concentrations in anaesthetic circuits and calibrating vaporizers.

In a gas chromatograph a sample, of the order of 0.5 ml. volume, of the gas or vapour mixture to be analysed is injected into a carrier gas stream at the entrance to the chromatographic column. The carrier sweeps the sample components through the column in which they are differentially retarded. As a result the various components emerge from the column split up with respect to time and their emergence is recorded by a detector unit. The chromatographic analyser shown used helium as the carrier gas and a thermistor thermal conductivity type detector. An electrically driven sampling valve takes samples for analysis automatically at pre-set intervals. Two columns are employed in parallel, one to separate the gases, the other to separate the vapours. The analyser on display had been made to the design of the Research Department of Anaesthetics by British Oxygen Cases Ltd.

The instruments described have all been developed for use in current research projects because there were no suitable commercial items available. The stand aroused considerable interest at the Exhibition, the most commonly voiced comment by visitors being, " Well, we never knew that all this was going on at the Royal College of Surgeons ".

Other exhibits of medical interest included the " Soniscope " by Faraday Electronic Instruments Ltd., of Sheerness, Kent. This is a compact electronic stethoscope with facilities for several people to listen simultaneously to a patient's heart sounds. Watson Ltd., of Barnet, manufacturers of the Barnet ventilator, were showing a prototype of the Howell's ventilator for use during anaesthesia and in the treatment of poliomyelitis. Watson were also showing a new cystoscope camera which is claimed to achieve an image quality, contrast and definition far in advance of anything that has previously been attained with this type of instrument. The Physics Department of Guy's Hospital Medical School were exhibiting an Electron Spin Resonance Spectrometer. The interest in this technique is centred chiefly in free radicals produced by irradiation in a study of irradiation damage such as is produced in radiotherapeutic treatment.

The Cambridge Instrument Company showed their Dye Dilution Curve Recording Apparatus Mk. II. This apparatus records accurately the dilution of a dye injected intravenously into the bloodstream and its circulation time. The advantages claimed for this version are: complete

elimination of artefacts due to arterial pulsation in the ear, linear response of the recorder to increasing concentration of dye when using a photo-electric cuvette or earpiece, and repeatable sensitivity from one curve to another. New Electronic Products Ltd. displayed a new battery-operated miniature electrocardiograph and medical pressure transducers and carrier amplifiers. Electronic Instruments Ltd. showed the latest version of their Direct Reading Blood pH Meter Model 48A. This is based on the well-known Vibron electrometer. The instrument has a basic range of 6.6 to 8 pH, giving a discrimination of plus or minus 0.005 pH units. An additional range, calibrated from 8.8 to 9.2 pH, is provided for standardizing the measuring system.

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PROCEEDINGS OF THE COUNCIL IN MARCH

AT AN ORDINARY MEETING of the Council on 9th March the President, Sir Arthur Porritt, gave a very interesting account of his recent world travels, mentioning the surgeons he had met, the surgical associations by which he had been entertained and the problems of surgical training which he had encountered.

The death of Lord Stopford, Honorary Fellow, was formally reported and the Council stood in tribute to his memory.

Mr. R. L. G. Dawson was appointed as Adviser in Training in Plastic Surgery, on the nomination of the British Association of Plastic Surgeons.

It was reported that Mr. W. A. Lisle Thompson, Fellow, had been appointed as Robert Jones Travelling Research Fellow by the University of Liverpool and the Liverpool Medical Institution. The appointment is made alternately by these two bodies jointly and by the College.

Mr. A. Lawrence Abel and Mr. C. Naunton Morgan were re-appointed as representatives on the Council of the Imperial Cancer Research Fund.

The congratulations of the Council were expressed to Professors G. W. Causey and G. J. Cunningham on having that title conferred on them by the University of London and to Dr. C. Long and Dr. J. R. Vane on their promotion to Readership in the University.

The Hallett Prize was presented to Captain W. C. Moffat, R.A.M.C., of the University of Glasgow.

The Handcock Prize was presented to M. H. Devereux, Member, of Guy's Hospital Medical School.

The thirtieth Macloghlin Scholarship was awarded to R. T. Watson of Marlborough College, who will hold it at Queens' College, Cambridge.

A Diploma of Fellowship in Dental Surgery was granted to Erwin Grossmann.

A Diploma of Membership was granted to E. J. W. Gumpert.

Licences in Dental Surgery were granted to 92 candidates.

The Council agreed to a request from the Government of Pakistan for a Primary F.R.C.S. Examination to be held in Lahore in January 1962, and is considering other Primary Examinations overseas.

Hospitals were recognized under paragraph 23 of the Fellowship regulations in accordance with the following list:

Hospitals	Posts Recognized		
	General (6 months unless otherwise stated)	Casualty (all 6 months)	Unspecified (all 6 months)
Sunderland — General Hospital (additional)			S.H.O. (Neurosurgery)
Caerphilly — District Miners' Hospital (additional)		S.H.O. (Orth. & Cas.)	
Harrogate and District—General Hospital (additional)		S.H.O. (Cas.)	
Londonderry — Altnagelvin Hospital (additional)	2 H.Os. 1 S.H.O.		
Whitehaven Hospital (additional)	2nd H.S.		
Warwick — Warwick and Warneford Hospitals (transfer of recognition)			*Under para.* 23 (*c*) H.O. (E.N.T.) at both hospitals instead of Regr. (E.N.T.) at the Warwick Hospital only
Birmingham — Dudley Road Hospital (redesignation)		*Redesignation* S.H.O. (Cas.) is now redesignated Regr. (Cas.)	
Bridge of Earn Hospital (redesignation)		*Previously Unspecified* 3 Orth. H.Ss.	
Ceylon—Government General Hospital, Kurunegala	R.S.O. 4 H.Os.		
Ceylon—General Hospital, Galle, and			at each hospital: *Under para.* 23 (*b*) H.S. (Ophth.) *Under para.* 23 (*c*) H.S. (E.N.T.)
Ceylon — Government General Hospital, Jaffna			
South Africa — Grey's Hospital, Pietermaritzburg (extension on recognition)	Surg. Regr.		

THE HUNTERIAN FESTIVAL

THE BIENNIAL HUNTERIAN FESTIVAL was celebrated in the College in customary form on 14th February, John Hunter's birthday.

In the unavoidable absence of the President in New Zealand, the ceremonies were conducted by the Senior Vice-President, Sir Stanford Cade.

The Festival consists of two major events, the Hunterian Oration and the Hunterian Dinner, both of which were held in the Edward Lumley Hall.

Sir Stanford Cade, Senior Vice-President, welcoming Sir Henry Dale, O.M., G.B.E., Chairman of the Wellcome Trustees, Honorary Fellow and a Member of the Court of Patrons of the College.

The Oration, by Sir Russell Brock, will be reported in a later number of the *Annals*.

After dinner the loyal toasts were followed, in accordance with tradition, by a silent tribute to the memory of John Hunter.

Sir Howard Florey, President of the Royal Society, proposed the health of the College and expressed his admiration for it in generous terms. The College realized, he said, that its reputation must rest on the additions to knowledge which it engendered, particularly in the experimental work of its scientific departments, and an indelible impression had been left by

John Hunter, an experimental pathologist among other things. The same methods of thought and criticism apply to clinical as to laboratory research, and fortunately all surgeons are experimentalists. Although the College was showing itself well aware of the importance of scientific research, he asked whether surgeons were being sufficiently encouraged to do research. The College had set a magnificent example in making the best possible use of its practical resources. He concluded with a personal tribute to Sir Stanford Cade, with whose name he coupled the toast of the College.

Prof. Digby Chamberlain greeting Mr. Richard Lumley and Sir Stanford Cade greeting Mr. Henry Lumley on their arrival at the College.

Sir Stanford Cade first apologized for the absence of the President, Sir Arthur Porritt, who was in New Zealand handing over the Presidency of the British Medical Association to another New Zealander. He then paid tribute to Sir Howard Florey's work and its beneficent influence on surgery. He proceeded to ask just what was the reason for John Hunter becoming the patron saint of the College, a question which he found as puzzling as Hunter's own character. At any rate the enquiring spirit of Hunter was now being perpetuated in the scientific departments of the College, each of which was mentioned and praised. The Hunterian Collection, our most priceless possession, was about to be worthily re-housed, and its new home would be the culmination of the rebuilding and enlargement of the College, planned by the vision of the late Lord Webb-Johnson and made possible by the generosity of captains of industry,

commerce and finance. Sir Stanford referred to the vigour of the post-graduate teaching given by the College and its Faculties, which had been so well illustrated at the recent meeting of the International Federation of Surgical Colleges. Three major developments since the last Hunterian Festival were specially mentioned—the creation of a Chair of Military Surgery, jointly with that at the Royal Army Medical College; the completion of the third phase of rebuilding; and the writing of the History of the College by Sir Zachary Cope, to-day celebrating his 80th birthday.

Professor Digby Chamberlain, Junior Vice-President, proposed the health of the guests and gave them a very friendly welcome to the College.

The reply was by the Rt. Hon. Lord Evershed, Master of the Rolls, who said that the guests were proud to be in the College doing honour to a great man. He commended not only John Hunter, but also modern surgery in its great services to humanity at all times and particularly during two world wars. Hunter, he reminded his hearers, had lived in a great English age, typified by Pitt in politics, by the architecture of the Georgian period, and by L. C. J. Mansfield (another Scot) in the Law. He recalled the occasion when circumstances had compelled him to find against the College in the Court of Appeal in its Charity case, an occasion which reminded him of the greatness of Lord Webb-Johnson.

The toast of the Hunterian Orator was proposed by Sir James Paterson Ross, past President, who likened this latest brilliant achievement of Sir Russell Brock to one of a series of ever higher peaks in the Scottish mountains.

Sir Russell Brock thanked Sir James for his words of praise and expressed his pride at being selected as Hunterian Orator. Having already spoken for an hour in the College and being now the last speaker, he reminded himself of the Chinese proverb, " It may be later than you think ".

Those present numbered 168 and, in addition to those already mentioned, included the French and Costa Rican Ambassadors, the High Commissioners for South Africa and Ceylon, the Marquess of Salisbury, the Minister of Health (the Rt. Hon. J. Enoch Powell, M.P.), and many others of distinction both in medicine and other walks of life.

FACULTY OF ANAESTHETISTS

PROFESSOR W. W. MUSHIN (Cardiff) has been elected Dean of the Faculty of Anaesthetists for the coming year and will take up his office on 28th June, and Dr. H. J. V. Morton (Hillingdon) has been re-elected Vice-Dean. Professor T. C. Gray (Liverpool) has been re-elected to the Board and Dr. C. F. Scurr, M.V.O. (Westminster Hospital), and Dr. J. D. Robertson (Edinburgh) have been elected to the vacancies caused by the retirement of Dr. John Gillies, C.V.O., and Sir Robert Macintosh.

PRESENTATION OF FELLOWSHIP IN HONG KONG

On Friday, 24th February 1961, there took place an event surely unique in the history of the College.

Two years ago a Fellowship was granted to Dr. G. H. Thomas, which he had been unable to come to Lincoln's Inn Fields and receive.

Council in their wisdom decided, after taking legal advice, that it was in order for the President in person to present the Diploma of Fellowship to Dr. Thomas in Hong Kong.

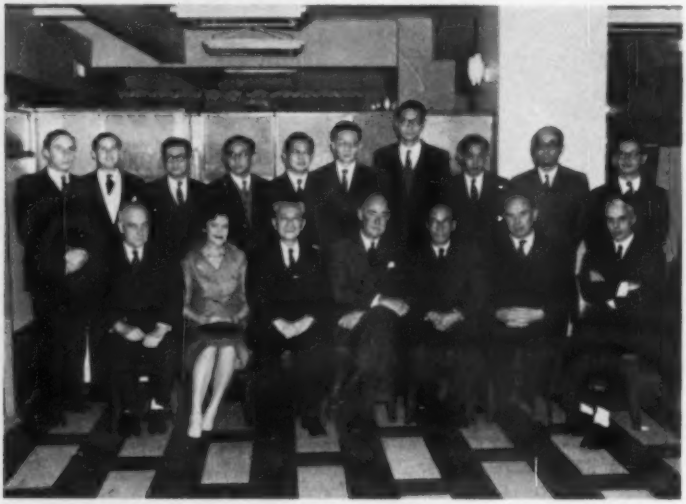

Fig. 1. The President with the twelve Fellows of the College and four Fellows of the Faculty of Anaesthetists who were present on the occasion of the admission to the Fellowship of Dr. G. H. Thomas during Sir Arthur's recent visit to Hong Kong. *Left to right: Back row:* G. H. Levien, F.R.C.S., Z. Lett, F.F.A.R.C.S., G. B. Ong, F.R.C.S., J. Chen, F.R.C.S., Y. K. Poon, F.F.A.R.C.S., T. H. K. Kong, F.R.C.S., M. H. Yeung, F.F.A.R.C.S., P. Y. Iu, F.R.C.S., O. L. Thomas, F.R.C.S., B. Ho, F.R.C.S. *Front row:* J. Gray, F.R.C.S., Miss N. S. G. Butt, F.F.A.R.C.S., A. W. Woo, F.R.C.S., the President (Sir Arthur Porritt), G. H. Thomas, F.R.C.S., Professor F. E. Stock, F.R.C.S., J. Thompson, F.R.C.S.

This ceremony took place in the Peking Restaurant of that city and in the presence of twelve Fellows of the College and four Fellows of the Faculty of Anaesthetists (Fig. 1) and their wives. The Fellows included amongst their number Dr. A. Woo, who was awarded a similar " twenty years' standing " Fellowship some years ago, and the occasion was admirably organized by Professor F. E. Stock, Professor of Surgery in the University of Hong Kong.

Clad in the latter's Fellow's gown, and to the accompaniment through the partition of the room of the sound of Chinese voices and the clink

of mah jong chips, the President, using the usual time-honoured words, duly admitted Dr. Thomas to the Fellowship (Fig. 2) and expressed his pleasure at being able so to do—especially to such a very worthy recipient.

Dr. Thomas replied in the following words:

" Sir Arthur Porritt, President of the Royal College of Surgeons of England:

" What words can I use to express my profound gratitude to you for so graciously consenting to attend this dinner and to admit me to the Fellowship of your illustrious College?

" It is my duty, and it would have been a very pleasant one, to make my pilgrimage to Lincoln's Inn Fields to pay homage to you and your august Council and to receive the diploma at your hands; but you, Sir, on learning of my difficulties of travel, have condescended to take the unprecedented step of performing this act outside of England, and to present me with the diploma in Hong Kong on your return journey from New Zealand.

Fig. 2. The President presenting the Diploma of Fellowship to Dr. G. H. Thomas. *Left to right:* Mr. Z. Lett, F.R.C.S., Mrs. Lett, Dr. G. H. Thomas, the President, and Professor F. E. Stock, F.R.C.S.

" Mr. President, I am truly undeserving of such generous consideration from you. I am only a simple practitioner working for and among the sick poor of this Colony. It is because I happened to be a product of the devoted labours of two British pioneer doctors who had worked in this part of the world some 75 years ago. They were Patrick Manson and James Cantlie (the latter a Fellow of our College). They, in collaboration with the London Missionary Society and others, founded the Hong Kong College of Medicine with the object of training Chinese young men in the art of Western medicine so that they might help their poorer countrymen. In 1889, the year that I was born, the first two graduates were produced, one of whom was the famous Sun Yat-sen, the Founder of the Chinese Republic. In 1912, this College ceased to function after producing the last small batch of graduates. I was one of them. It has been my endeavour since that day to try to live up to the ideals and hopes of the founders; and in that endeavour I have been abundantly blessed with the loving companionship of my dear helpmeet, who has shared the rough and the smooth throughout the 41 years of our married life.

" Mr. President, my wife respectfully joins me in thanking you most sincerely for what you have done for me this evening."

The ceremony was followed by a very excellent Chinese dinner of twelve courses, at which the President proved himself the least able manipulator of chop-sticks present!

The occasion gave ample evidence of the loyalty and goodwill of the Hong Kong Fellows and the College need have no fear of the esteem and respect in which it is held in that distant and fascinating British Colony.

DONATIONS

DURING THE LAST few weeks the following generous donations have been received:

Appeal Fund—Donations:

£250	Samuel Osborn & Co., Ltd.
£100	Trustees of the late The Rt. Hon. Baron Austin
£52 10s. 0d.	Herbert Morris, Ltd.
£50	William Baker (Leicester), Ltd.
	The Haberdashers' Company
	Tempered Group, Ltd.
	Union Corporation, Ltd.
	Mrs. D. H. Leather
£48 10s. 0d.	Lady Paterson Ross
£26 5s. 0d.	Barratt & Co., Ltd.
£25	Frears & Blacks, Ltd.
	B.B. Chemical Co., Ltd.
	Broadhurst & Co. (Gadbrook), Ltd.
	W. R. Swan & Co., Ltd. (Sheffield)
£22 8s. 3d.	The Marick Singers
£21	Glamour Girl, Ltd.
	Gresham House Estate Co., Ltd.
	Nicholls & Wileman, Ltd.
	British Steam Specialties, Ltd.
	Portland Shoes, Ltd.
£20	Leadbeater & Peters, Ltd.
	C. Czarnikow, Ltd.
£17 2s. 10d.	Hazel, Watson & Viney
£15 15s. 0d.	D. Sirkin, Esq.
	Mrs. B. C. Bervon
	G. Folwell & Son, Ltd.
£10 10s. 0d.	The Brooke Tool Group Charitable Trust
	Tizer, Ltd.
	L. Warry, Esq.
	J. E. Slater, Esq.
	Escombe McGrath & Co., Ltd. (further gift)
	Austen Ridge, Ltd.
£10	A. M. Walker, Esq.
	The Southsea Luncheon Club
£5 5s. 0d.	J. B. Rawson, Esq.
	Dr. D. W. Kent and A. J. Amos, Esq.
	Weston-Webb, Ltd.
	Eaton & Booth, Ltd.
	Knowles & Sons, Ltd.

£5 5s. 0d.	Lancashire Condenseries, Ltd.
	George Tarrah, Ltd.
	Ambrose Shardlow & Co., Ltd.
£5	George Sharman, Ltd.
	Anonymous donation
	J. Booth & Sons, Ltd.
£3 3s. 0d.	J. Sermin & Sons, Ltd.
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UNITED KINGDOM INCOME TAX RELIEF

[*This note was published in the* ANNALS *in April* 1959, *and is reprinted for the benefit of a number of new Fellows who were not given this information at the time they received their Diplomas.*]

THE ROYAL COLLEGE of Surgeons of England has been approved by the Commissioners of Inland Revenue for the purposes of Section 16, Finance Act, 1958, under which an annual subscription to an approved body is allowable as a deduction from the emoluments of any office or employment assessable to United Kingdom income tax under Schedule E.

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The relevant passages of the letter read as follows:

"Commencing with the year to 5th April, 1959, a member who is assessable to income tax under Schedule E in respect of the emoluments of an office or employment is entitled to a deduction from those emoluments of the whole of the annual subscription which is due and payable by him to the society in the income tax year provided that:

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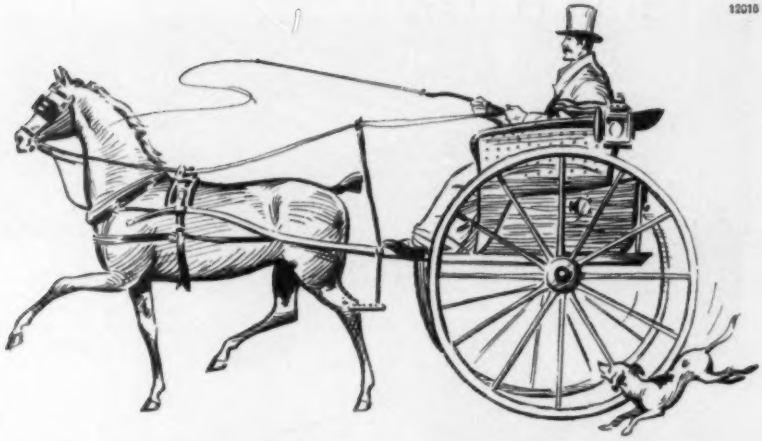
DIARY FOR APRIL

Tues.	18	4.15	DR. A. A. BARTON—Arnott Demonstration—The replication of species.
Wed.	19		Second L.D.S. Examination begins.
Thur.	20	5.00	PROFESSOR D. P. CHOYCE—Hunterian Lecture—The development and uses of all-acrylic anterior chamber implants in ophthalmic surgery.
Fri.	21		Anaesthetic course ends.
Sat.	22		Last day for applications for Lectureships. Surgical Lectures and Clinical Conferences end.
Mon.	24		Dental Lectures and Clinical Conferences begin.
		5.00	PROFESSOR W. F. W. SOUTHWOOD—Hunterian Lecture—Villous tumours of the large intestine.
Tues.	25		Last day for nomination of candidates for the Council. Final Fellowship Examination (Ophthalmology and Otolaryngology) begins.
		5.00	MR. TERENCE WARD, C.B.E.—Dental Lecture—Fractures of the mandible.
		6.00	SIR HARRY PLATT, BT.—Ruscoe Clarke Memorial Lecture—
		6.15	MR. N. L. ROWE—Dental Lecture—The treatment of unerupted and impacted teeth.
Wed.	26		PROFESSOR D. SLOME—Arnott Demonstration—The physiology of the vestibular apparatus.
Thur.	27	4.00	PROFESSOR WILDER PENFIELD, O.M., C.M.G.—Lister Memorial Lecture—The brain's record of experience.
		5.00	PROFESSOR G. L. HOWE—Dental Lecture—The complications of extraction—I.
		6.15	PROFESSOR G. L. HOWE—Dental Lecture—The complications of extraction—II.

DIARY FOR MAY

Mon.	1		Final Fellowship Examination (General Surgery) begins.
Tues.	2	5.00	DR. H. E. LEWIS and DR. J. P. MASTERTON—Arris and Gale Lecture—Polar physiology—its development in Britain.
		5.00	MR. B. E. D. COOKE—Dental Lecture—Lesions of the oral mucosa—I.
		6.15	MR. DAVID PATEY—Dental Lecture—Diseases of the salivary glands.
Thur.	4		D. Path. Examination begins.
		5.00	MR. B. E. D. COOKE—Dental Lecture—Lesions of the oral mucosa—II.
		5.30	DR. R. BODLEY SCOTT—Otolaryngology Lecture—Blood diseases in relation to otolaryngology.
		6.15	MR. R. L. G. DAWSON—Dental Lecture—Cleft palate.
Fri.	5		Voting papers for Council issued. Basic Sciences Lectures and Demonstrations end.
Tues.	9	5.00	PROFESSOR H. G. RADDEN—Dental Lecture—The healing of extraction wounds.
		6.15	PROFESSOR C. D. CALNAN—Dental Lecture—Allergy and allied problems affecting the mouth and face.
Thur.	11	2.00	Ordinary Council.
		5.00	DR. F. STANSFIELD—Bland-Sutton Lecture—
		5.00	DR. A. R. KELSALL—Dental Lecture—Recent advances in medical treatment with special reference to dentistry.
		6.15	MR. J. WATSON—Dental Lecture—Head injuries.
Tues.	16	5.00	PROFESSOR R. B. LUCAS—Dental Lecture—Pathology of oral neoplasms—I.
		6.15	MR. H. M. PICKARD—Dental Lecture—Anterior restorations.
Thur.	18	5.00	PROFESSOR R. B. LUCAS—Dental Lecture—Pathology of oral neoplasms—II.
		6.15	MR. S. H. WASS—Dental lecture—Osteomyelitis and actinomycosis.
Fri.	19	5.00	Board of Faculty of Dental Surgery.
Sat.	20		College closed.
Mon.	22		Whit Monday. College closed.
Tues.	23	5.00	MR. G. T. HANKEY—Dental Lecture—The diagnosis and treatment of some more rare oral surgical conditions.
		6.15	PROFESSOR H. C. KILLEY—Dental Lecture—Oral surgery in relation to prosthetic problems.
Thur.	25	5.00	MR. H. P. COOK—Dental Lecture—Dental problems in the treatment of malignant disease of the jaws.
		6.15	MR. J. N. W. MCGREGOR—Dental Lecture—Surgical anatomy of the jaws.
Tues.	30	5.00	MR. G. L. FORDYCE—Dental Lecture—Fractures of the maxillae and multiple facial fractures.
		6.15	MR. I. R. H. KRAMER—Dental Lecture—Changes in the dental tissue due to operative procedures.
Wed.	31		Primary F.R.C.S. Examination and Final F.D.S. Examination (Part I) begin.

12010



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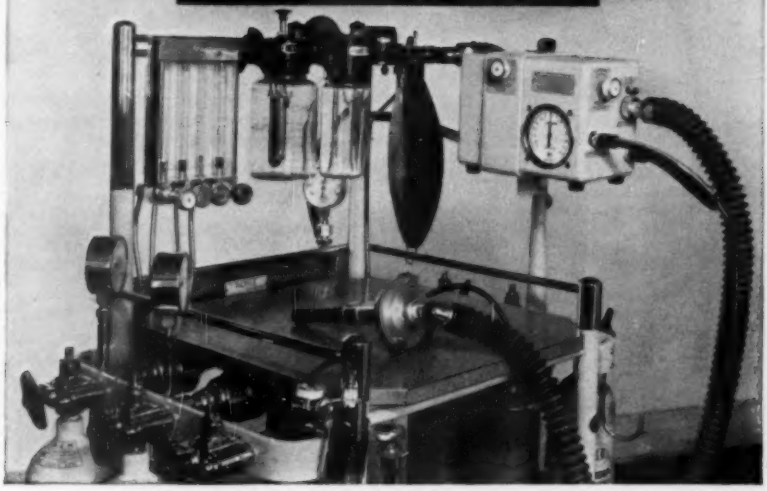

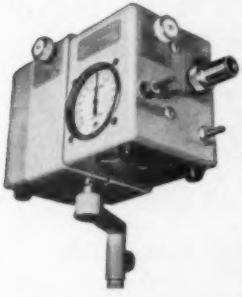

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Annot., Lancet, i, 375, 1960.

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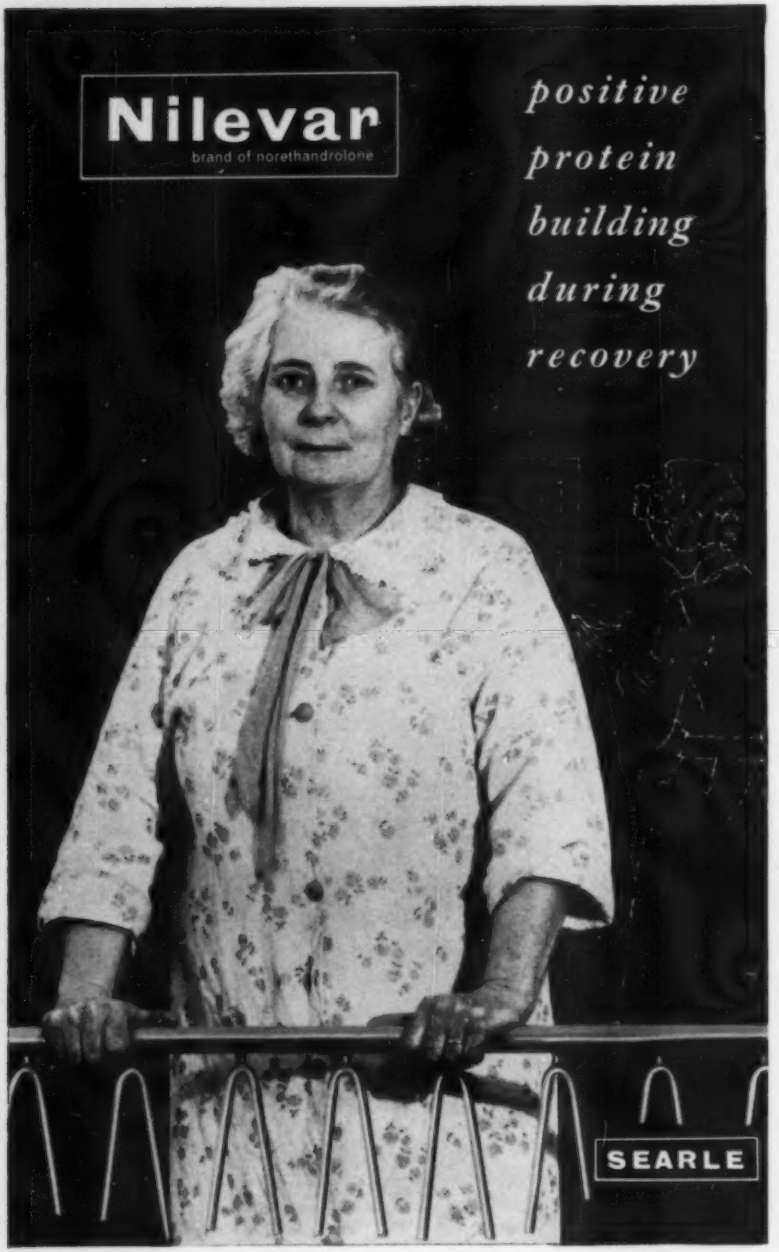
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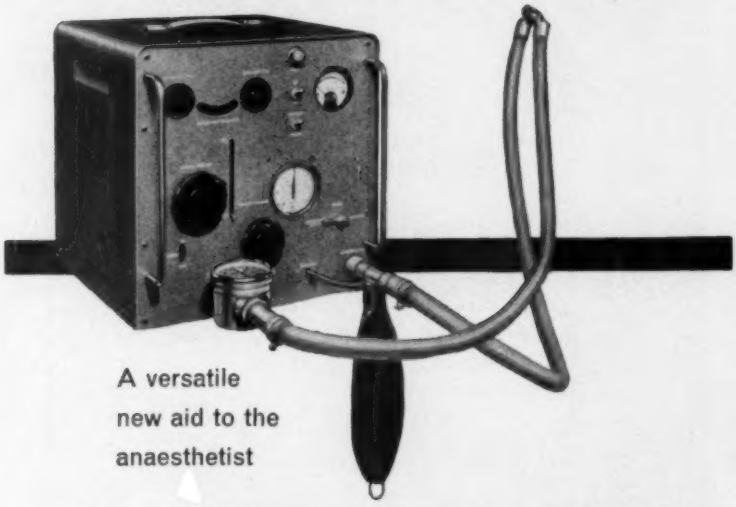

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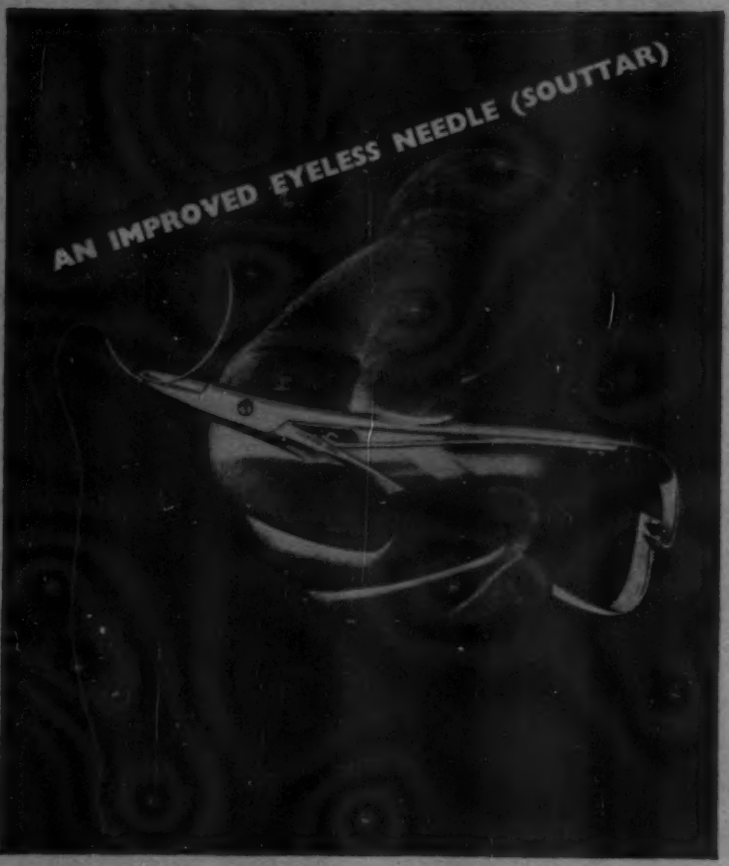

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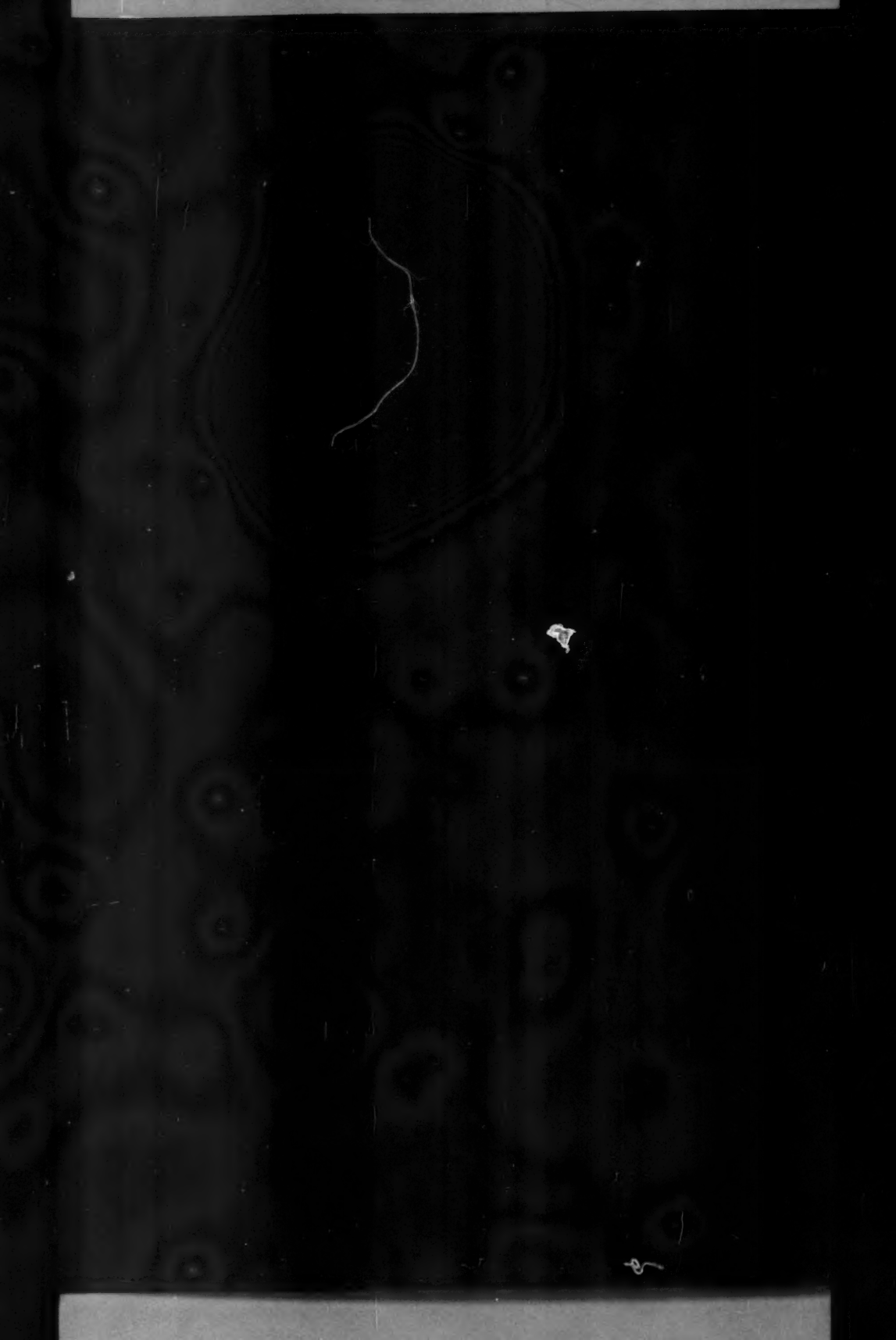
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